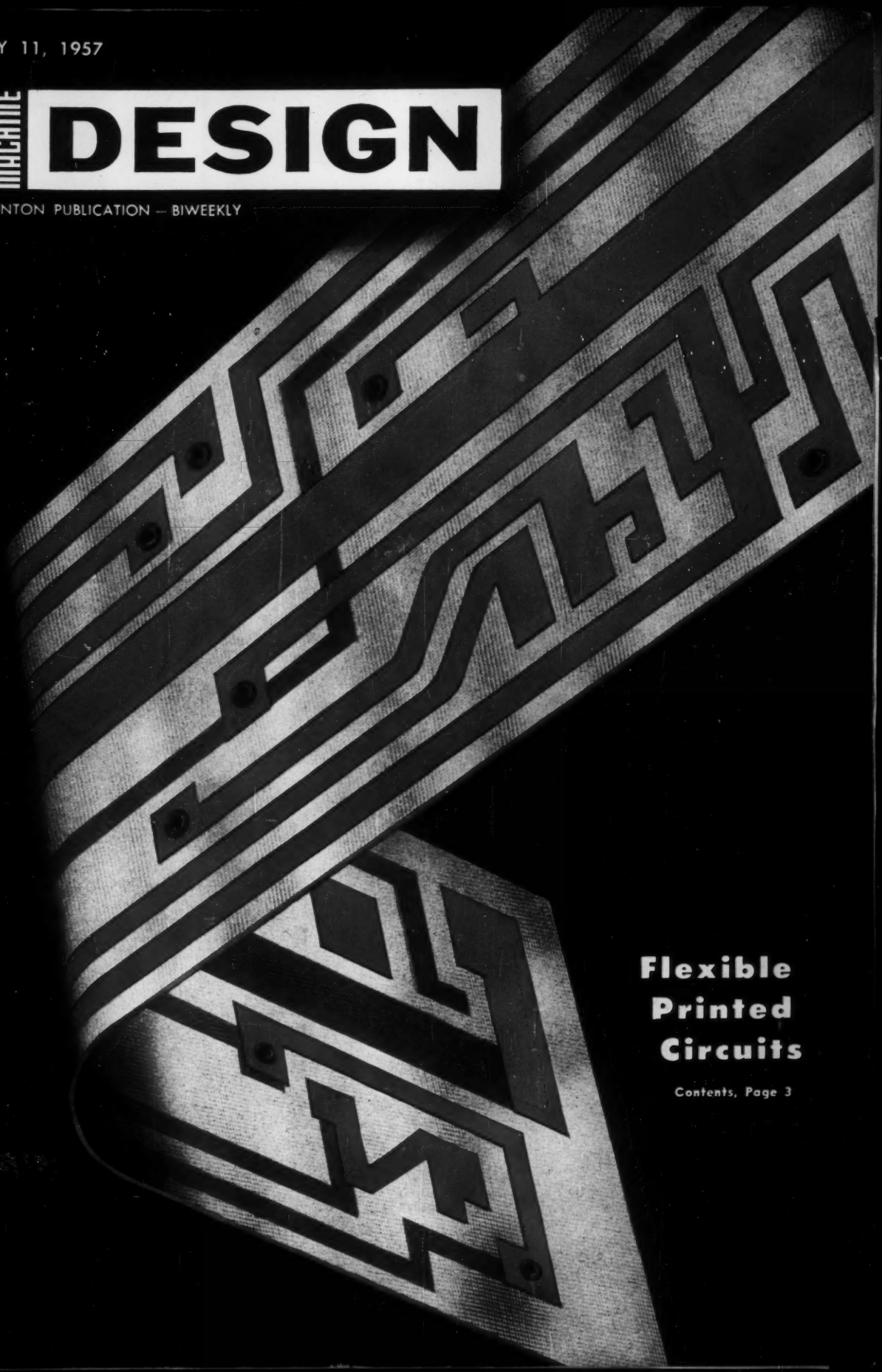
JULY 11, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Flexible Printed Circuits

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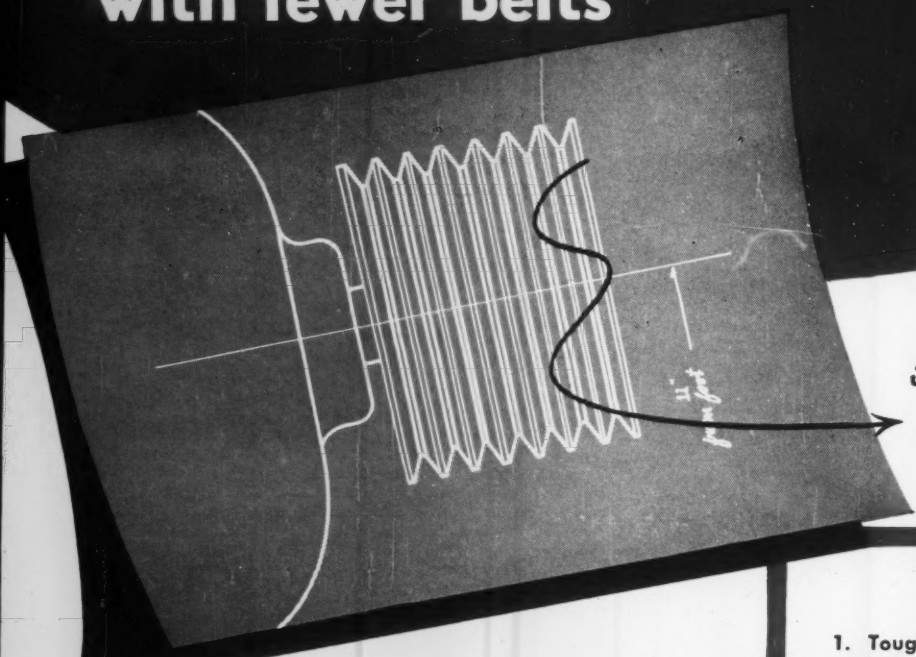
FARNSWORTH

Cut sheave width and weight...

get same horsepower with fewer belts



5 Gates Super Vulco Ropes do the work of 7 standard V-belts

Where space is limited and weight a factor, design your drive with this important fact in mind:

5 Gates Super Vulco Ropes do the work of 7 standard V-belts

That's because a Gates Super Vulco Rope has 40% more horsepower capacity — delivers more horsepower per dollar invested than any standard V-belt drive. Sheaves with fewer grooves cost less... weigh less... take less room. Drive design is invariably improved.

A wealth of drive data is quickly available to you. Simply call your nearby Gates distributor for a Gates V-belt specialist. Stocks carried in industrial centers around the world.

The Gates Rubber Company
Denver, Colorado

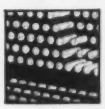
Gates Distributors are in the Yellow Pages

Gates

The Mark of Specialized Research

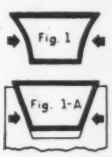
No other V-Belt has ALL these advantages

1. Tough, resilient Tensile Cords



Super strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

2. Concave Sidewalls (U.S. Pat. 1813698)



Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. Flex-Weave Cover (U.S. Pat. 2519590)

A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life... more power available to driven machine.

4. High Electrical Conductivity

Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant

Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

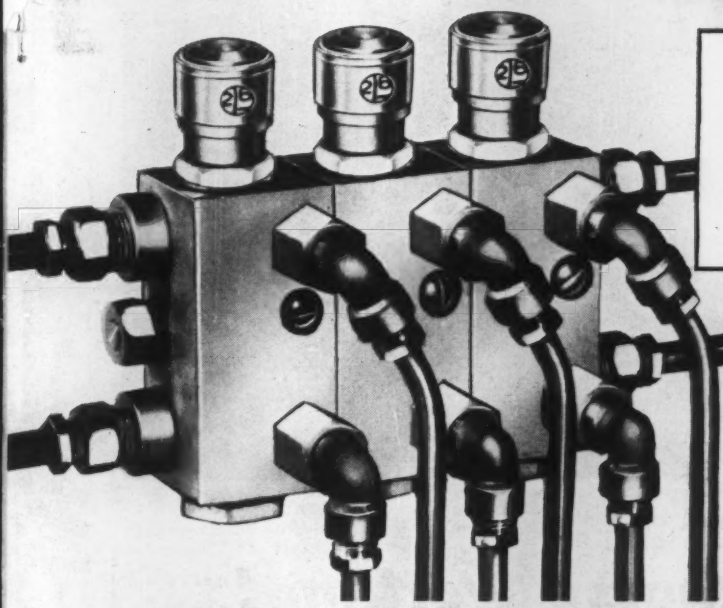
TPA 248 A

Gates Super Vulco Rope Drives

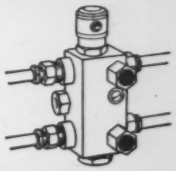
Design to meet Toughest lubrication requirements

with this centralized ALEMITE ACCUMATIC SYSTEM

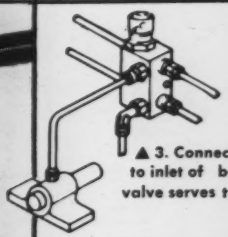
Can be designed into any machine in 4 easy steps!



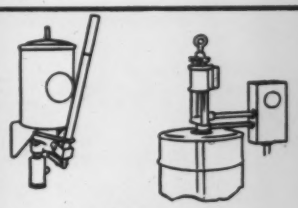
1. Remove grease cups or grease fittings.



2. Connect each valve in system to its two lubricant supply lines.



▲ 3. Connect valve outlets to inlet of bearings. (Each valve serves two bearings.)



4. Provide central pump for supplying lubricant to system.

Type II Accumatic Valve

Handles difficult multiple-bearing lubrication under all conditions. Fully sealed for clean lubrication of power shovels, cement kilns, conveyors—any outdoor or indoor installation. Operates whether completely immersed in fluid . . . covered by dirt or grit . . . or protected by anti-corrosive paint. For fluid oil or light grease. Four sizes, delivering from .050 to .500 cu. in. of lubricant.

Fully hydraulic—no springs to adjust or replace.

Now available with Lubrication Recording Cycle Counter—for a fully automatic record of bearing lubrication!

Tests show no appreciable variation in the amount of lubricant discharged after 73,312 cycles—equal to *122 years of twice-a-day service!*

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

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Division of STEWART-WARNER CORPORATION

STEWART SW WARNER

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Please send me my free copy of the complete Accumatic Catalog.

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Company .....
Address .....
City ..... Zone ..... State .....

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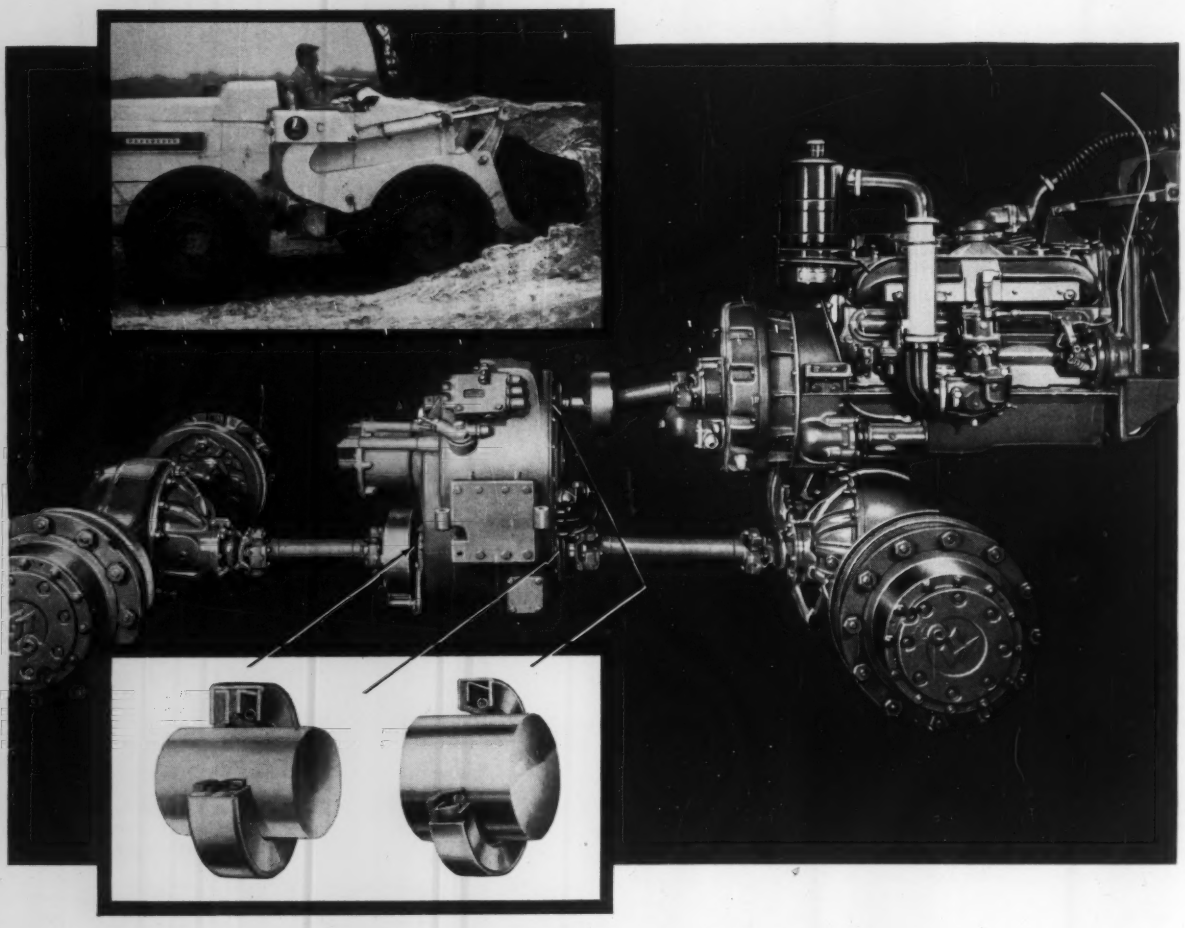

Keeps a workhorse working!

C/R lifeguards the power-shifted transmission in the big Hough "Payloader"

The new Hough Model HH "Payloader" is a big, tough tractor-shovel that wades through hard, rugged work day after day without flinching. Its power-shifted transmission makes it one of the fastest-maneuvering, easiest-handling tractor-shovels on rubber. To keep the transmission humming, two shafts must be protected: an input shaft turning up to 2,200 r.p.m., and an output shaft operating at speeds up to 3,000 r.p.m. All vital parts of the transmission are pressure-lubricated—the SAE 10 HD oil *must* be retained; dirt and grit *must* be excluded. C/R Type P and F Oil Seals with the Conpor K-400 sealing elements . . . specified by Hough engineers . . . have been performing with complete dependability well beyond the required 2,000-hour service life.

If you have similar problems involving lubricant retention or dirt exclusion, C/R Oil Seal engineers can help you. They'll select the correct seal for your application or gladly cooperate with you on special designs.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

OIL SEAL C/R DIVISION
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July 11, 1957 Volume 29—No. 14

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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Penton Building, Cleveland 13, O.

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Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

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NEW! CLARK Type "AL" AUTOMATION CAM LIMIT SWITCH

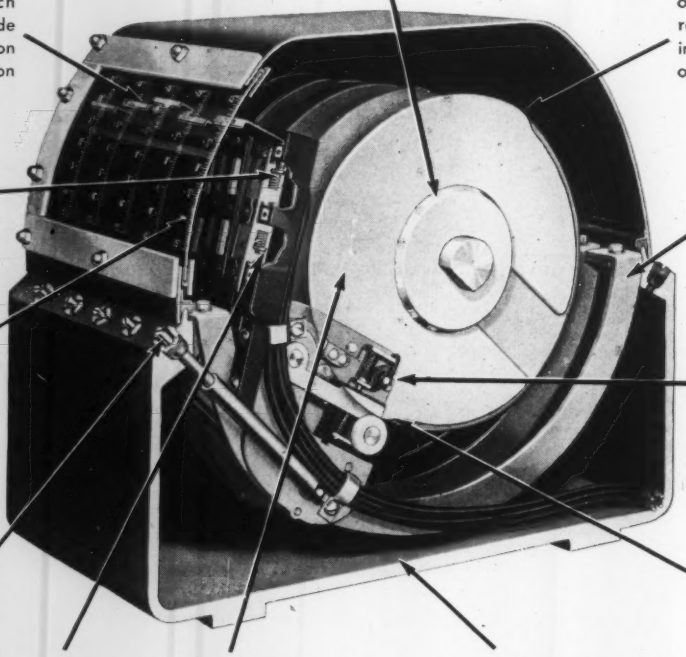
— ADJUSTABLE IN MOTION —

GREATER SAFETY! GREATER FLEXIBILITY! GREATER PRECISION! EASIER MAINTENANCE!

PRECISION—Cams can be loosened and reset without removing them from shaft. Graduations facilitate making precise settings.

PRECISION—Graduated scales for adjustment of each switch unit are printed on inside of clear plastic window. Provision is made for circuit identification visible through window.

SAFETY—Switch unit is actuated only when roller is riding on raised segment of cam. Jogging in reverse does not alter sequence of operations.



FLEXIBILITY—An additional isolated contact—easily convertible in the field—is available for each switch unit, to permit control of two circuits from a single unit.

FLEXIBILITY—Rear-mounted switch units can be added to permit micro-adjustment of both make and break of a single circuit operated by a single cam.

MAINTENANCE—All contacts clearly visible through plastic window. Inspection may be made without removing switch cover.

PRECISION—Snap-action, latching type switch units make possible smooth performance, being operated by constant acceleration cams eliminating "bumping".

PRECISION—Position of switch unit can be adjusted to micro-accuracy over a 30° range from outside housing *while machine is in motion.*

SAFETY—Cams force contacts open and hold them open—assuring postive break.

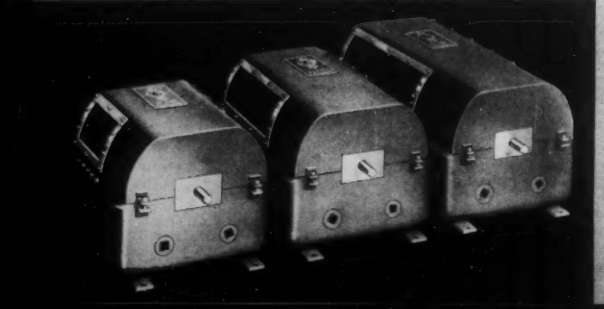
SAFETY
Heavy-duty 15 ampere industrial-control type contacts will not jar open with severe vibration.

PRECISION
Large (7-in.) twin-disc adjustable butterfly cams operate each circuit. Wide variety of cam equipment available to cover range of contact operations from 15° to 345°.

MAINTENANCE—Enclosure with cast aluminum base and welded steel cover meets NEMA 4 (watertight) and NEMA 12 (automotive and J.I.C.) standards. Oil resistant rubber gasketing and packing under pressure completely seal enclosure.

These new CLARK Type "AL" Cam Limit Switches meet the rugged requirements of large presses, and have broad application on many other machines where accurate and dependable sequence operation of multiple circuits is required. They are ideal for use where it is advantageous to make precision adjustments while machines are in motion, and are particularly suitable for many applications in the field of Automation.

3 basic sizes: 5 cam, 9 cam and 12 cam. The 12-cam size can be modified to accommodate up to 16 cams. With double-sided switch arrangements, each size can provide additional switch units up to one less than the number of cams.



For more information, write for Bulletin 102-AL

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Engineering News Roundup

Racing, Speed Publicity Halted By Auto Makers

Emphasis To Be On Safety, Reliability and Comfort

DETROIT, MICH.—Unanimous resolution of the Automobile Manufacturers Association recommends that member companies take no part in auto racing or other competitive events involving speed tests. It urges that members discontinue all publicity regarding "actual or comparative capabilities of passenger cars for speed, the specific engine size, torque, horsepower, or ability to accelerate or perform, in any context that suggests speed." All volume producers of passenger cars in U. S. are members of the Association.

According to the resolution, manufacturers should "encourage owners and drivers to evaluate passenger cars in terms of useful power and ability to afford safe, reliable and comfortable transportation, rather than in terms of capacity for speed."

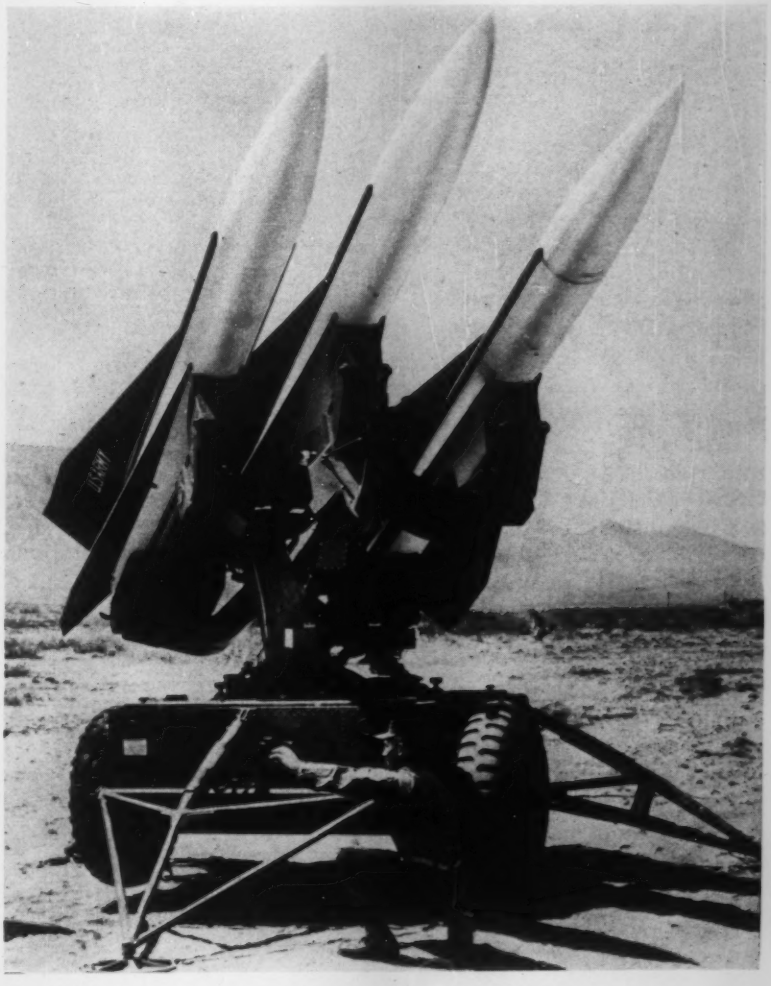
Aircraft Collision Avoidance Subject of New Research

Device To Function in Planes Flying at Mach 3; 100,000 Ft.

BALTIMORE, MD.—Development of a practical device to prevent aircraft collisions is subject of a contract between Bendix Aviation Corp. and the Air Force. Schedule calls for completion in March, 1958, of a flight-tested research model to be delivered to Wright Air Development Center.

The contract provides a general description of what the final device might be like:

1. Maximum detection range of the system would be sufficient to provide ample warning and collision avoidance maneuvering time at closure rates up to Mach 6.
2. Protected volume surrounding the aircraft, from which collision avoidance information is required, would be essentially spherical in shape. This protect-



LOW FLYERS' NEMESIS is this new Army missile which carries radar highly effective in detecting and tracking low-flying aircraft in the blind zone of conventional radars. Named Hawk, the missile was developed at Raytheon Manufacturing Co. The Hawk system can be emplaced in fixed installations and can also accompany fast-moving troops in the field. Fixed emplacement for a Hawk battery covers 40 acres; has underground missile magazines. Missiles themselves are 16 ft long; 14-in. diam; use solid fuel.

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ing sphere may be modified so that maximum detection range is in the directions of greatest vulnerability to collision.

3. A warning device would be included to inform the pilot that another aircraft is nearby. The system would include means for automatically executing collision avoidance maneuvers by introducing appropriate electrical signals into the autopilot or flight control system of the aircraft.
4. Size of the equipment would not exceed 2500 cu in. Installed weight would not exceed 50 lb.
5. Overall system would be suitable for all-weather use in aircraft with speeds up to Mach 3.0 at altitudes up to 100,000 ft.

Design objectives include making the system suitable for both civil and military use and adoption of primary radar methods.

U.S. Army photograph

PNEUMATIC ASSAULT BOAT developed by the Army Corps of Engineers carries 15 men at 7.1 mph when powered by a 25-hp outboard or 3.3 mph when hand paddled. Constructed of neoprene-coated nylon, the boat consists of a main flotation tube, an air-mat bottom, a thwart tube connecting the main flotation tube amidship, and a 4-in. diameter spray rail around the main flotation tube. The main tube, 18 in. in diameter, has six compartments, four of which can be punctured without putting the boat out of action. Inflated, the boat is 17 ft long, 5 ft 8 in. wide. Collapsed, it weights 255 lb.

Utility Outstanding Feature Of Italian Cars New in U.S.

NEW YORK, N. Y.—The Fiat line of automobiles from Italy is now available here in two series of cars comprising seven body styles. The smaller 600 series includes a two-door sedan, convertible and station wagon. The 1100 series has four-door standard and touring sedans, station wagon and a two-place convertible.

All of the cars are powered by four-cylinder engines ranging from 22 to 53 hp. Engine of the 600 series is in the rear. Manual shift transmission with four forward speeds is standard.

The 600 "All Service" will accommodate six persons or 770 lb. As a utility vehicle, seats can be collapsed to provide a loading platform. Seats in another 600 series model fold down to provide sleeping accommodations for two adults.

The 1100 "Family Sedan" is also utilitarian with adjustable seats and a fifth door at the rear to facilitate loading. A touring sedan in this series has conventional seat arrangement, is described as a medium capacity car with deluxe appearance.

Engine Specifications

	600 Series	1100 Series
Type	In-line, OHV	In-line, OHV
No. cyls.	4	4
Bore & Stroke (mm),	60 x 56	68 x 75
Displ. (cc)	633	1089
Comp. ratio		7 to 1; 8 to 1*
Bhp, max	22	40 @ 4400 53 @ 5260*

Dimensions

	600 Series	1100 Series
Wheelbase (in.)	78¾	92⅛
Length (in.)	140¾	150⅝
Width (in.)		57¼; 57⅞†
Height (in.)		58⅝; 50⅜†

*1100 TV series. †1100 TV convertible.

Italian Fiat two-door 600 Standard Sedan recently introduced in the U. S.

Front Cover

Printed circuits that can be bent around corners, or formed into cylinders or spirals, provide high versatility in design of electronic equipment. George Farnsworth's cover highlights the article by George Voida on Page 124.

WHEN SINGLE OR MULTIPLE THREAD WORMS MUST BE EXTREMELY ACCURATE AND UNIFORM

. . IT'S A JOB FOR

G. S. MEN . . METHODS . . MACHINES

SEND FOR..

6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course.

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Top precision in the G. S. 5 and 8 thread hardened and ground Worms pictured above, is consistently maintained on G. S. precision equipment. Accuracy and uniformity of lead, and thread spacing accuracy, of vital importance in precision multiple Worms, is under the strict control of highly skilled workmen. The 4 thread Worm has hobbed threads, case hardened and polished. This method is more economical and a great degree of accuracy is maintained through G. S. specialized heat treating. The 3 thread Worm is hobbed and brushed. This most economical method is recommended for *unhardened* multiple thread Worms. The single thread Worm is precision ground from the solid, on a heat treated shaft. ★ G. S. men, methods and machines are developed to produce a degree of accuracy, efficiency and economy that will cut costs and improve product performance for you. Modern equipment and extensive inspection facilities assure absolute control of quality. Customer furnished blanks or a complete job, optional. Send drawings or details, today.

41 Years of Specializing in Small Gearing!

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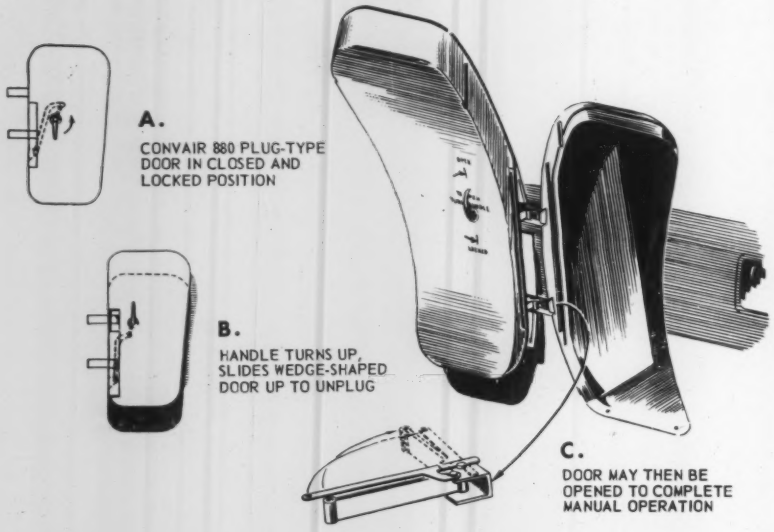
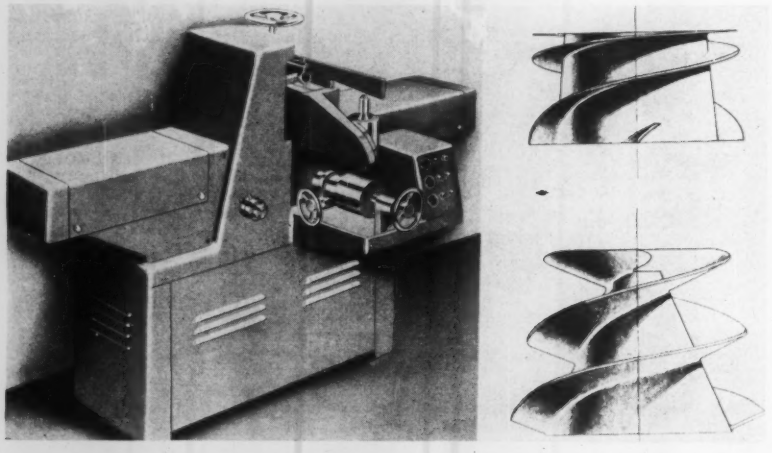

A.
CONVAIR 880 PLUG-TYPE DOOR IN CLOSED AND LOCKED POSITION
B.
HANDLE TURNS UP, SLIDES WEDGE-SHAPED DOOR UP TO UNPLUG
C.
DOOR MAY THEN BE OPENED TO COMPLETE MANUAL OPERATION

PLUG-TYPE DOOR will be used on Convair model 880 commercial jet transports. The 615-mph planes will have pressurized cabins to permit flights at altitudes up to 40,000 ft. Under these conditions, doors must not open accidentally and should not depend on latches to keep them in place. Tapered design fills the bill. The door is side hinged, vertical sliding, closed and opened by 180-degree turn of handle. Shear ledges along each side of the door fit into recesses in the frame. These vertical elements carry the pressure from cabin interior. Convair says its door is easy to install and maintain, light in weight, useful for both passenger and cargo compartments.



VERSATILE VANE GENERATOR is this new unit developed particularly for machining the blades of jet engine compressors or blowers. Prototype of model 6-6-720-P, shown, by Machine Tool Div., Nationwide Engineering Service Inc., performs machining in 10 minutes that requires 80 hours by step milling and hand finishing with conventional equipment. The new machine can generate vanes concave or convex in shape, with straight or tapered sides, and perpendicular to either the spiral axis or the hub of the vaned product. Vanes may have variable lead, as shown above, top right, or constant lead, lower right. Maximum machine capabilities are: work diam, 6 in.; work length, 6 in.; vane rotation, 720 deg; lead angle, 45 deg; cutter diam, ¼-in.; hub angle, 45 deg. Air-driven cutter speeds are 18,000 to 35,000 rpm; optional mechanical cutter spindle runs at 1500 to 10,500 rpm.

Topics

Balloon ascent of 96,000 ft has been made, setting a new record for manned, lighter-than-air flight. Previous record was 76,000 ft. The flight, made by Capt. J. W. Kittinger Jr., was part of a series of tests to determine man's endurance at high altitudes.

• • •

You can't get sociable in an automobile because passengers ride on two rows of benches—so says Ruth Glennie, who does interior decorating for Buick. Miss Glennie proposes a swivel-type front passenger's seat so that the person sitting there could ride backwards and join in the back-seat conversation. Would this be known as the backward look?

• • •

Flat TV picture tube should be perfected in ten years, according to Ross D. Siragusa, president of Admiral Corp. New wide-angle, 110-deg deflection picture tubes in current Admiral sets are housed in cabinets less than 16 in. deep. Six years ago, 21-in. sets with their 70-deg tubes had cabinets over 27 in. deep.

• • •

Aerial color photographs reveal clues to location of mineral deposits. High-altitude shots are studied with three-dimensional viewing equipment to reveal details in the lay of the land that would not be detected in a cursory ground survey. Changes in color tones, undetectable in black-and-white photographs, indicate geological characteristics that point to oil and mineral deposits.

• • •

Paint film 0.001-in. thin—or electroplating or metal overlay—can be measured for quality control purposes with a new instrument developed by General Motors researchers. The portable Laminagage nondestructive tester can be used for a high rate of production testing.

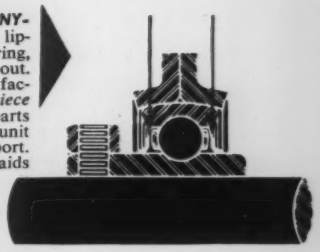
• • •

International Council of the Aeronautical Sciences is the first world-wide organization formed specifically to extend collaboration in all scientific areas pertaining to mechanical flight, according to an announcement by the Institute of the Aeronautical Sciences. First international congress of the ICAS is scheduled for Madrid in 1958.

Precision ... self-alignment

EVEN IN THIS LOW-COST BEARING

BEST SEAL AVAILABLE ANYWHERE! Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Bearing is greased at the factory and shipped in *one piece* . . . no juggling of sundry parts in assembly—simply slip unit on shaft and bolt to support. Its compactness further aids design flexibility.

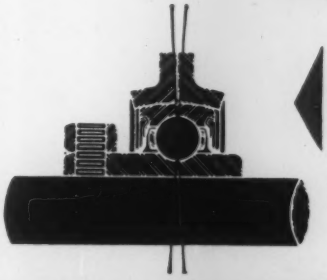


LINK-BELT JPS-200 ball bearings maintain capacity despite shaft and support deflection

IN rugged field service, supporting structures on farm machinery and similar equipment undergo inevitable weaving. Shafts, too, are subject to dynamic deflections. Answer: *self-alignment* — the ability of Link-Belt bearings to adjust under these conditions. And it's yours *at low cost* in this precision Link-Belt ball bearing.

Equally important, Series JPS-200 bearings achieve their economy with *no loss of efficiency*. They combine sturdy pressed-steel housings with standard, full-capacity Link-Belt ball bearings.

Folder 2517 has complete data on the Link-Belt JPS bearing series, and Book 2550 covers the entire Link-Belt bearing line. Get both from any of 40 Link-Belt offices.

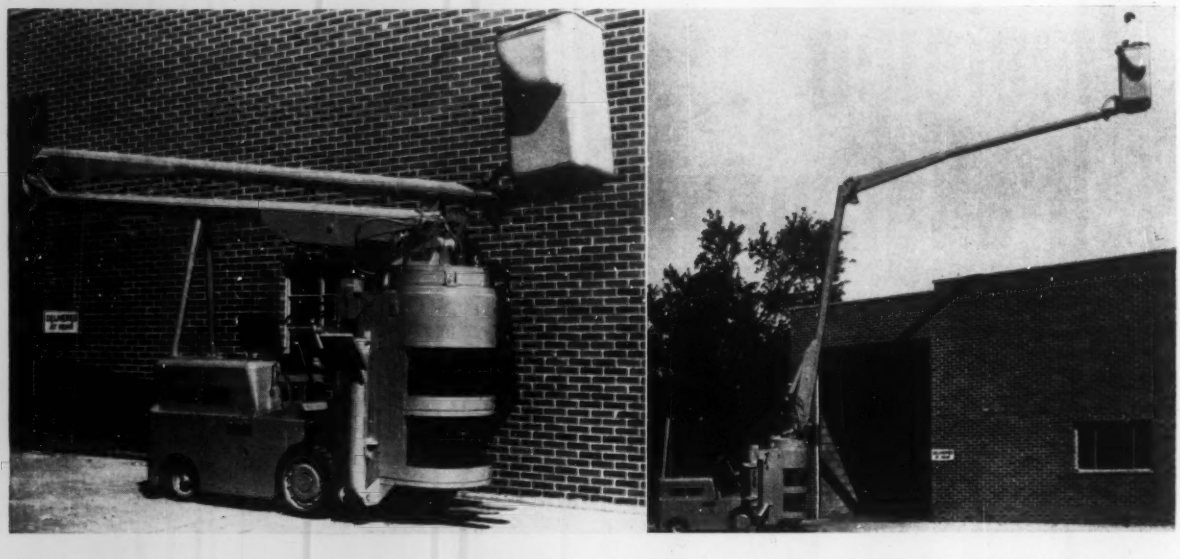


FREE ROLLING AND FULL LOAD CAPACITY are maintained even under shaft or support misalignment with Link-Belt self-aligning feature. Extra-long inner ring of bearing assures proper load distribution. Heavy spring-locking collar firmly secures bearing on shaft.

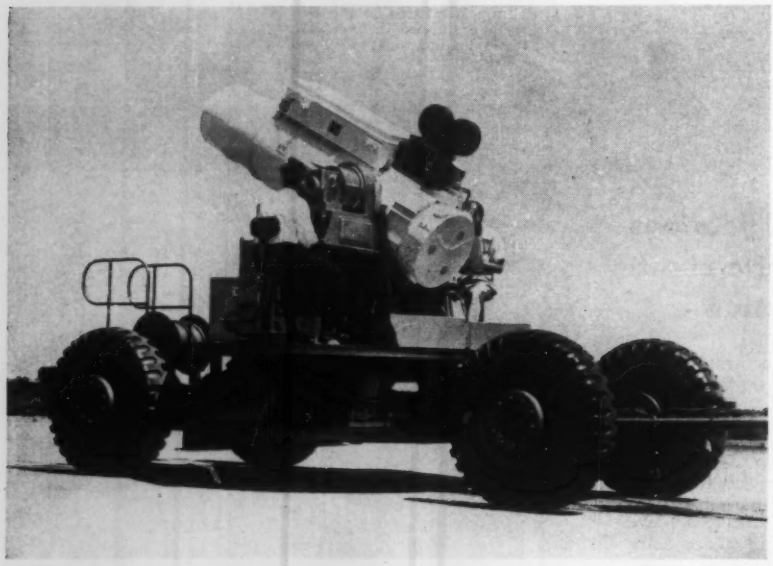
LINK LB BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.339-A



INDUSTRIAL NOOK AND CRANNY PROBE, designed for simple, rapid attachment on conventional lift trucks, carries maintenance or production personnel to plant areas formerly not readily accessible. Designated model 4-40I, Hi-Ranger, the unit is made by Mobile Aerial Towers, Inc. Operator, tools and materials, up to 300 lb total, ride the basket which houses a single control for 3-D motion of the jointed arm, hydraulically actuated. Maximum reach of the unit is 40 ft above the floor. Outriggers steady the truck for extension of the boom to either side. Accessories attachable to the basket include lighting fixtures, electric lines and pressure-sensitive bars for stopping all motion during performance of delicate operations.



FLIGHT HISTORY OF MISSILES, aircraft and bombs will be recorded by this mobile optical tracking system. Unit will record altitude data, spin rates, and correlated time data. It will photograph a 2 in. by 7 in. object at altitude of 4 mi. System consists of a 100-in. focal length reflecting telescope equipped with 70 mm movie camera and two sighting cameras. By changing lenses, focal length of primary telescope can be moved from 100 to 200, or 300 in. Variety of color and neutral density filters are built in. Unit will operate remotely by radar, or by visual observation. Entire system is mounted on 90-mm gun mount. Called the Telescopic Photographic Recorder, it was developed for the Air Force by Perkin-Elmer Co.

Unitized Aluminum Body Makes Light, Versatile Army Truck

DEARBORN, MICH.—Integral body-frame structure of aluminum, claimed to be first in the the automotive industry, has been developed by Ford Motor Co. in constructing a new Army utility vehicle. Body structure, spot welded throughout, weighs 124 lb. This is about one-third the weight of steel body prototypes.

Resembling a jeep, the vehicle is said to be lighter and stronger, more economical to operate and better performing than any comparable military truck. For greater stability, center of gravity is 3½ in. lower than that of the present Army quarter-ton truck. It provides room for four passengers and has 30 per cent greater cargo area. Wheelbase is 85 in., overall length, 132 in.

Specially developed four-cylinder, ohv engine is said to provide higher speed and better acceleration than any current military vehicle. Engine, radiator, clutch, transmission, and transfer cases are installed in a single package. This

FACTS

about

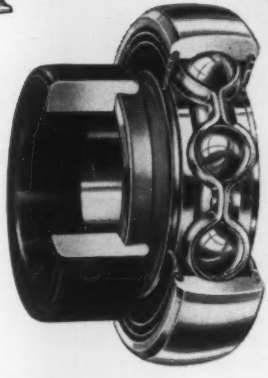
NEW DEPARTURE BALL BEARINGS

NOW A NEW DEPARTURE IN PILLOW BLOCKS

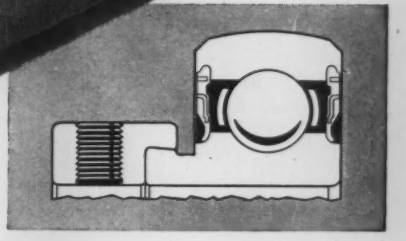
- Clean, rigid, compact design.
- Free of any lubricating fixtures.
- New Departure ball bearings sealed and lubricated-for-life.
- Pillow Blocks easily mounted without special tools.
- Only high capacity precision ball bearings used.
- Accommodates any misalignment.
- 31 shaft sizes, ½" through 2 7/16".
- Interchangeable with most makes.

Send for Catalog PBC for complete details.

GREASE SEALED IN
DIRT SEALED OUT
with
FAMOUS SENTRI-SEAL



New Departure Pillow Blocks employ the performance-proved New Departure Type AE Adapter ball bearings with spherical O.D. for alignability and steel-reinforced Sentri-Seals for long life protection against dirt or grease leakage.



The bearings are easily applied to the shafting and are positively locked in position with an eccentric cam locking collar and set screw.

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

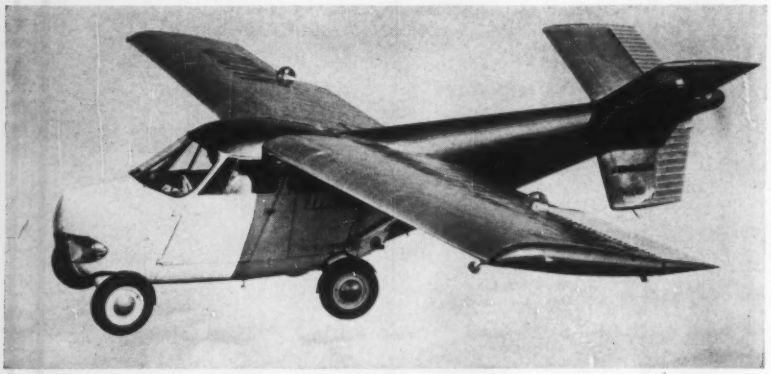
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Circle 409 on page 19

entire assembly can be removed and changed in one hour.

Because suspended brake and clutch pedals are used, there are no holes in the floor and the vehicle is adaptable to flotation. It will transport four soldiers with cargo across inland waterways.

One of the early prototypes was successfully parachuted to earth twelve times as part of a military testing program.



PRODUCTION AUTOMOBILE is this airplane now in the production stage by Aerocar Inc. Conversion to car, complete with turn signals, takes five minutes. Wings and tail fold into detachable trailer unit. Flight cruising speed is over 100 mph, ceiling 12,000 ft, range 300 mi. Car unit has fiber glass body, front-wheel drive, safety pop-out windshield and two-tone exterior finish. Maximum road speed is 67 mph.

Stored Storage Batteries Possible Through New Design

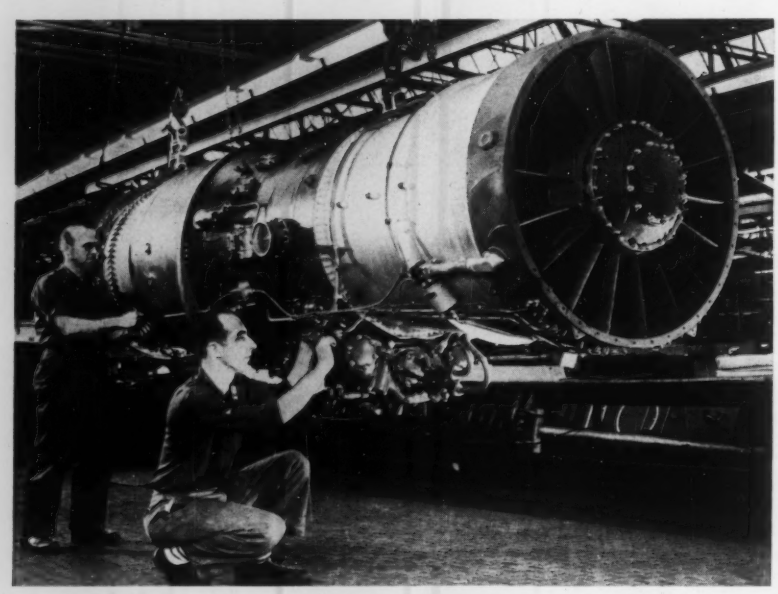
Unique Power Source Valued for Emergency Use

ROCHESTER, N.Y. — Batteries that can remain in inert storage for years and be brought to full power in 0.1-second have been developed by Eastman Kodak Co. and G. & W. H. Corson Inc.

The new battery is activated by an internal burst of ammonia vapor. Efficient operation at temperatures ranging from below −65 F to +165 F is claimed by its makers. The battery may be tested at any time during its virtually unlimited "shelf life" by the admission of ammonia vapor to the hermetically sealed container—then deactivated by vacuum removal of the vapor.

Almost unlimited variety in container size is possible by simple structure of the unit. It consists of cathode and anode joined by a blotter-like "bridge," plus an ammonia-vapor triggering device.

Individual cells capable of internal series arrangement to produce up to 6000 v make the battery adaptable to a variety of industrial power needs.



MOST POWERFUL production turbojet engine this side of the Iron Curtain is claimed for the new J-75 model by Pratt & Whitney Aircraft. Its rated thrust of 15,000 lb is augmented by an afterburner. The new engine looks like its forerunner, the J-57, but the J-75 produces nearly 50 per cent more dry thrust; has outstandingly low specific fuel consumption and lower specific weight. The J-75 will power the Air Force F-105 fighter, the Navy P6M water-based bomber, and the Boeing 707 and Douglas DC-8 airliners.

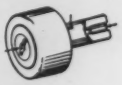
American Institute of Electrical Engineers announces the election of Walter J. Barrett as president for 1957-58. Mr. Barrett, who is affiliated with New Jersey Bell Telephone Co., has been active in AIEE committee work, has served in such capacities as a director of the institute and treasurer.

Vice presidents elected were Benjamin R. Teare Jr., Carnegie Institute of Technology, Pittsburgh; Herbert W. Oetinger, Duke Power Co., Charlotte, N. C.; Albert G. Johnson, Omaha Public Power District, Omaha, Neb.; Orien A. Gustafson, Pacific Northwest District, General Electric Co., San Francisco; and Gordon F. Tracy, University of Toronto. L. F. Hickernell, Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y., was elected treasurer.

Performance features of TORRINGTON CAM FOLLOWERS

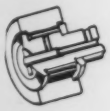
Heavy sectioned outer race to absorb high rolling and shock loads.

Integral stud for cantilever mounting, case-hardened, with tough core for high strength to withstand shock loads.



Easily relubricated at either end or through cross hole in stud. Ends accommodate standard drive grease fittings or plug seals.

Full complement of small diameter rollers for maximum radial capacity and efficient anti-friction performance.



Races precision ground for even load distribution and uniform low end play.

Built to "FOLLOW THROUGH" under high shock loads

Every feature of the Torrington Cam Follower is designed to insure efficient performance and long service life under heavy rolling and shock loads in cam or track follower service.

Precision made throughout, Torrington Cam Followers are available in sizes from ½" to 2¼" OD. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our engineering staff will be glad to work with you in applying these reliable units to your cam-controlled or track-type equipment. You can depend on Torrington Cam Followers to "follow through" on the job because every element is designed for ultimate capacity. *The Torrington Company,* Torrington, Conn.—and South Bend 21, Ind.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

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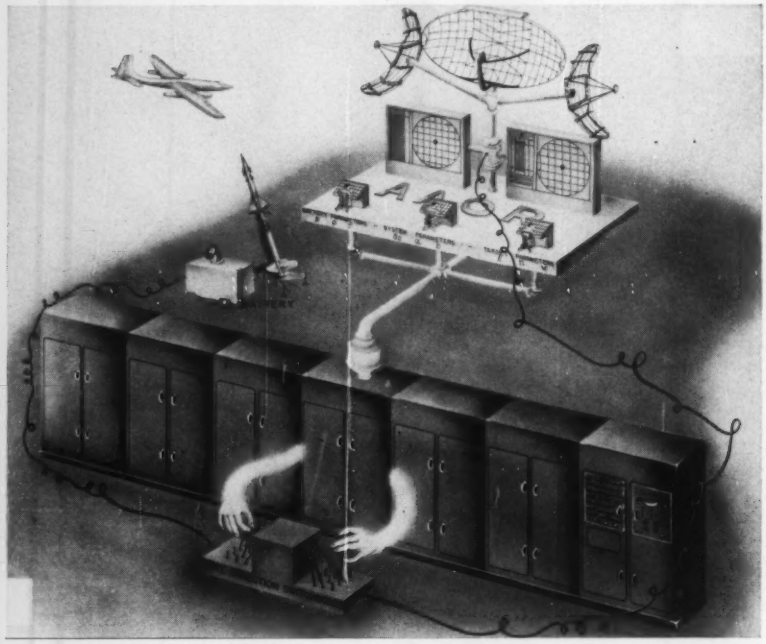
Device Uses Powder Blast To Halt Steam Catapults

WASHINGTON, D.C. — Runaway steam catapults on aircraft carriers will be actually blasted to a halt by a device developed jointly by Naval Ordnance Laboratory and Naval Air Engineering Facilities.

The new safety device prevents the catapult from reaching excessive speed if it accidentally disconnects from the aircraft it is launching. Named the RSP—Runaway Shot Preventer—the system cuts off the steam supply if the shuttle of the catapult uncouples from the plane prematurely.

If a catapult accelerates suddenly to excessive speed, the RSP explodes a charge of gunpowder that closes the steam valve in 0.2-second. Then a water brake safely stops the catapult's moving shuttle before extensive damage is done.



FIRING ORDERS are handed to air defense weapons by this electronic control system capable of performing 136,000 mathematical steps in less than a second. Factors involved in split-second calculations include missile time from battery to exploding point, effective range, point of intercept, kill probability, percentage of total bomb damage attacking planes can inflict, and target priority of a group of attacking planes. Multiweapon Target and Battery Evaluator, 29 ft long and 7 ft high, has a 9-ton air conditioner. It was conceived by Army Signal Laboratory, developed by Burroughs Corp.

EFFI—Electronic Fiber Fineness Indicator—is new system for measuring and grading textile fibers. Unit rapidly scans fibers on a slide and computes average diameter of selected group. Developers are Top Co. and National Research Corp.

Society of the Plastics Industry Inc. announces the election of Russell Mahaney as president for the next two years. He was also elected to the SPI board of directors. Mr. Mahaney is president and director of St. Regis Paper Co. and general manager of its Panelyte Div., New York.

Automotive Gas Turbine Ready Soon for Trucks, Buses

Heavy Duty Applications Cited by GM Engineers

ATLANTIC CITY, N. J.—Automotive gas turbines are "practical and feasible" for heavy duty and military vehicles. "No additional engineering breakthroughs are required to put heavy turbine vehicles on the road," according to three General Motors research engineers.

Appearing before the SAE annual meeting, William Turnen, Robert Schilling, and E. L. Baugh described research on the recently announced Chevrolet Turbo-Titan, a heavy duty truck tractor.

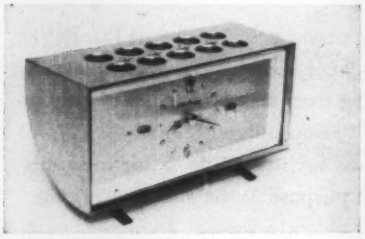
Under a normal rating of 50,000 gross combined weight, the unit has an acceleration improvement (0 to 40 mph) of 27.5 per cent over a standard piston truck engine. On hills the turbine showed a 17 per cent "gradeability" improvement.

Comparative constant-speed, level-road fuel economy tests, matching the Turbo-Titan with a standard production truck, also produced good results.

To make a comparison with a production truck, gross load of the Turbo-Titan was increased 15,000 lb to maintain a more nearly equivalent performance.

At top speed on the highway, the turbine engine operated with fuel costs "the same or less than those of production piston engines." Moreover, gas turbines will run equally well on several fuels, from gasoline to diesel No. 2, allowing use of cheapest or most readily available fuels.

Other favorable details of the turbine engine were outlined. "The gas turbine delivers more power per cubic foot of installed space



EXPOSURE TO LIGHT from time to time will run this new solar clock indefinitely. Equivalent of a day of incandescent light or sunlight provides correct time for a month. A series of silicon solar cells generates voltage to charge an accumulator cell; this in turn operates an electric clock mechanism. Capacity of the energy storage unit is sufficient to keep clock functioning for more than a year without any light. If the clock stops after long storage in the dark, exposure to light restarts it. Product of General Time Corp., the unit will be in production soon.

or per pound of installed weight than present reciprocating engines. Its transmission requirements can be simplified, to minimize driver training, by elimination of the torque converter and its cooling equipment."

Durability tests with Turbo-Titan were admitted to be incomplete but, "in general, durability has been excellent despite the usual run of minor difficulties with new engine development.

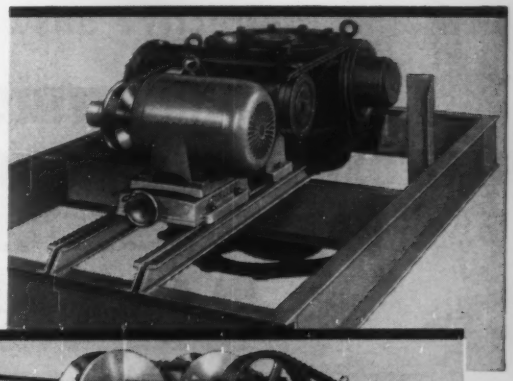
"Being a true air-cooled engine, the turbine does not require bulky radiators, large and noisy fans or antifreeze, and no difficulties were experienced in these areas. . . . Oil consumption has been extremely low. As oil does not come in contact with combustion products or unburned fuel, it stays clean for long periods."

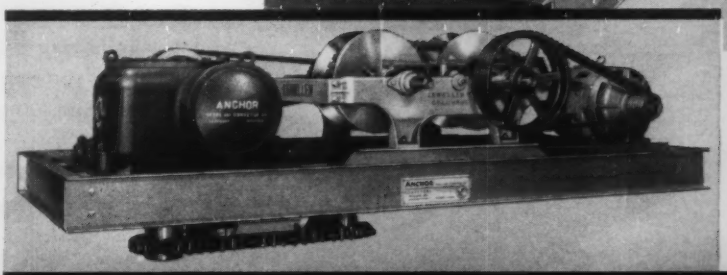
"The ignition system is very simple and is required only during starting. The fuel control system which replaces the carburetor is relatively simple and has operated trouble free."

Carbon formation or fouling in the engine's regenerator, which retrieves heat from exhaust gas and delivers it to the engine's air intake, has not been a problem be-

(*Continued on Page* 22)

Anchor Steel & Conveyor Co., Detroit, incorporates Lewellen V/S Transmissions and Variable Pulleys in their head shaft drives.





FOR CHAIN, BELT OR SCREW
CONVEYORS
LEWELLEN
V/S TRANSMISSIONS
VARIABLE PULLEYS

WHEN A LEWELLEN V/S TRANSMISSION OR VARIABLE PULLEY DRIVES THE HEAD SHAFT, movement of materials and products becomes as flexible as every production demand.

Transfers are timed and feeds are proportioned at whatever rate the operation requires.

Flow is smooth, continuous . . . and coordinated.

ANY SPEED IS IMMEDIATELY AVAILABLE AND CONVENIENTLY CONTROLLED, manually or automatically, over the entire range of operation.

Lewellen V/S Transmissions are rated to 60 H.P. in speed ranges to 20:1.

Lewellen Variable Pulleys are rated to 15 H.P. in speed ranges to 4:1 singly, 10:1 in pairs.

Choose the variable drive that meets your specific need from Lewellen's wide selection.

Shall we send you our new catalogs?

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.
Distributors In All Industrial Areas • In Canada—Peerless Engineering Sales Ltd., Toronto-Montreal

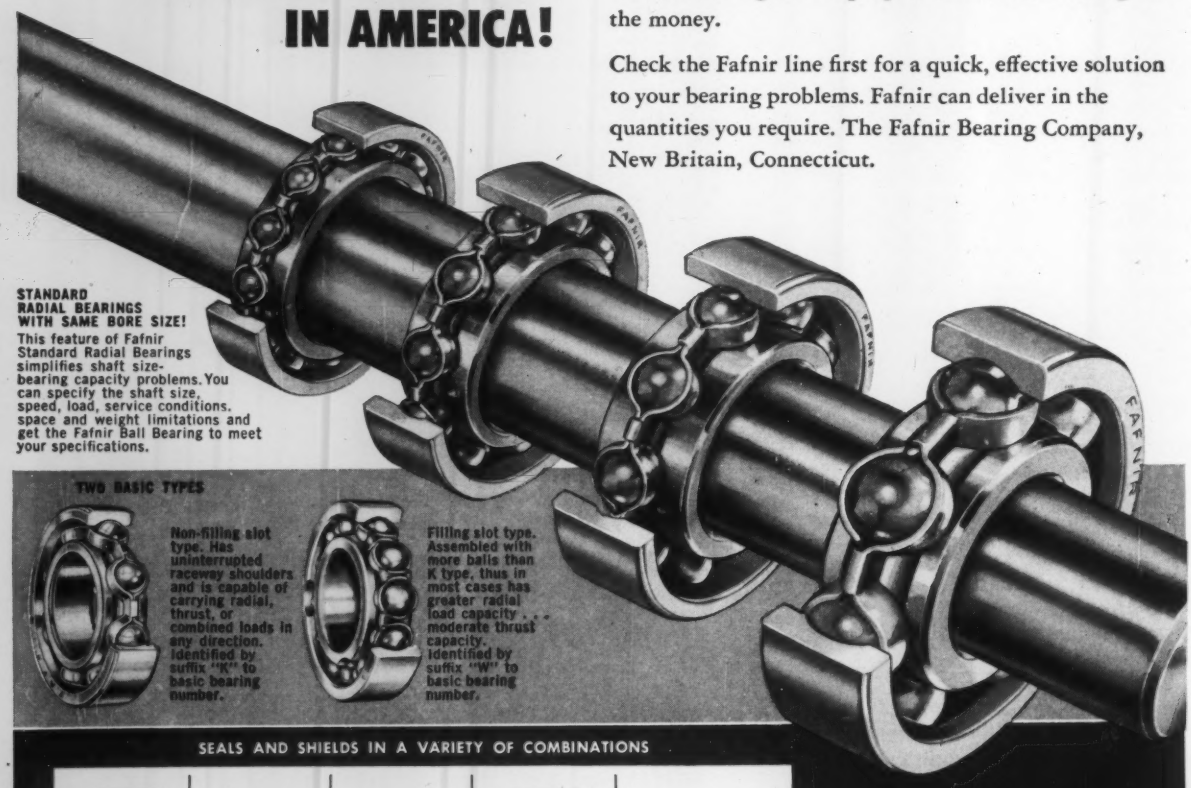
Circle 411 on page 19

For the most effective answers to your bearing problems...

FAFNIR OFFERS THE MOST COMPLETE LINE OF BALL BEARINGS IN AMERICA!

Whatever your bearing needs, your best bet is Fafnir. The reason . . . Fafnir makes America's most complete line of ball bearings, ranging from standard radial to custom-made jet engine types. Various tolerances and combinations of seals and shields enable Fafnir to supply the best bearing for the purpose — the *most* bearing for the money.

Check the Fafnir line first for a quick, effective solution to your bearing problems. Fafnir can deliver in the quantities you require. The Fafnir Bearing Company, New Britain, Connecticut.



STANDARD RADIAL BEARINGS WITH SAME BORE SIZE!
This feature of Fafnir Standard Radial Bearings simplifies shaft size-bearing capacity problems. You can specify the shaft size, speed, load, service conditions, space and weight limitations and get the Fafnir Ball Bearing to meet your specifications.

TWO BASIC TYPES

Non-filling slot type. Has uninterrupted raceway shoulders and is capable of carrying radial, thrust, or combined loads in any direction. Identified by suffix "K" to basic bearing number.

Filling slot type. Assembled with more balls than K type, thus in most cases has greater radial load capacity . . . moderate thrust capacity. Identified by suffix "W" to basic bearing number.

SEALS AND SHIELDS IN A VARIETY OF COMBINATIONS

1 Shield

1 Felt Seal and Shield

1 Mechani-Seal and Shield

1 Plya-Seal

Wide Type Bearing with Plya-Seals

2 Shields

2 Felt Seals

2 Mechani-Seals

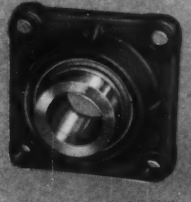
2 Plya-Seals

Wide Type Bearing with Mechani-Seals

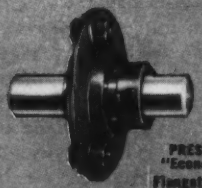
FAFNIR BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

A COMPLETE LINE OF HOUSED UNITS including:

CAST IRON PILLOW BLOCKS
LAK illustrated



CAST IRON FLANGE CARTRIDGES
LCJ illustrated



PRESSED STEEL "Economy" UNITS
Flangette illustrated

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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NEW

KAYDON THIN SHELL NEEDLE BEARINGS

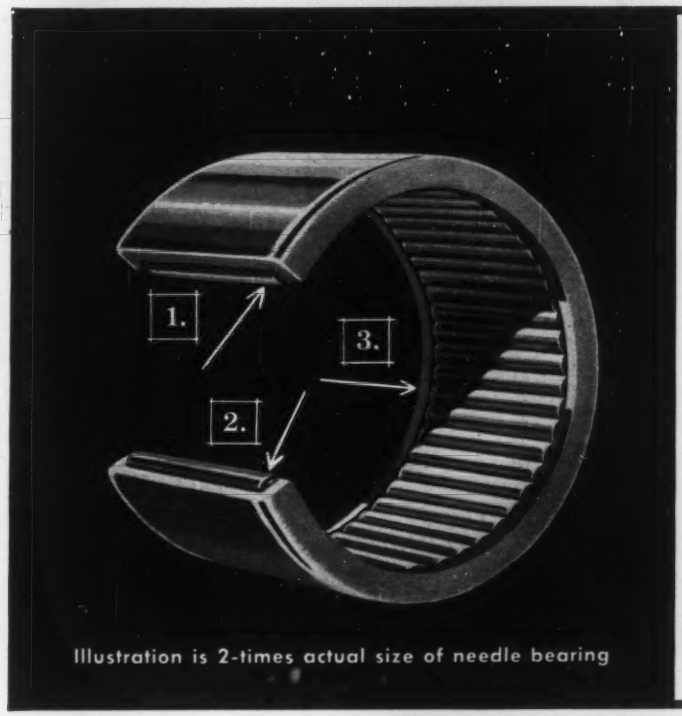
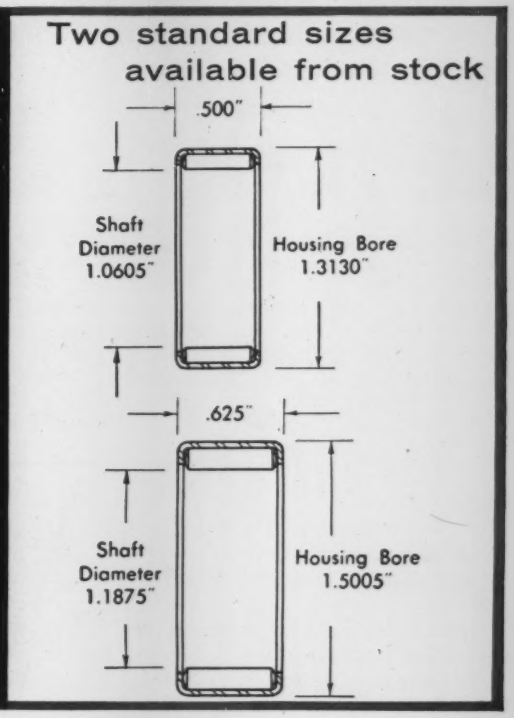


Illustration is 2-times actual size of needle bearing



You get these Kaydon design advantages:

1. Greater effective length needle rollers for MORE CAPACITY (41% on ½" width) . . . LONGER LIFE (2.8 times as much on ½" width) 2. Simplified construction that SAVES you money 3. Pre-packed lubrication that SAVES assembly time.

These new thin-shell bearings were developed with the co-operation of the FORD MOTOR COMPANY for use in FORD-O-MATIC and MERC-O-MATIC automatic transmissions

Kaydon's new thin-shell needle bearing gives more of everything — *more economy . . . more capacity . . . plus longer life* than any other comparable bearing. That's because of Kaydon's greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

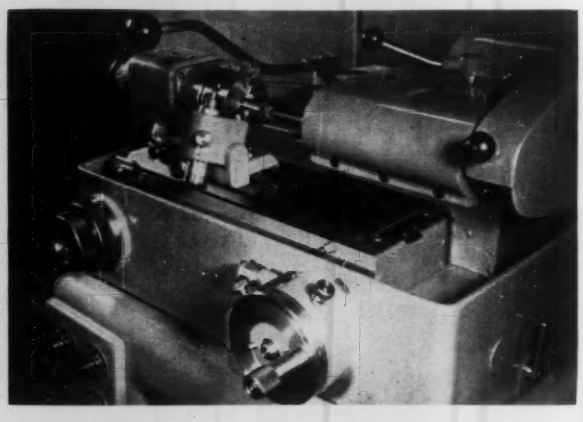
For complete specifications, ask for Data Sheet No. K562 — write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

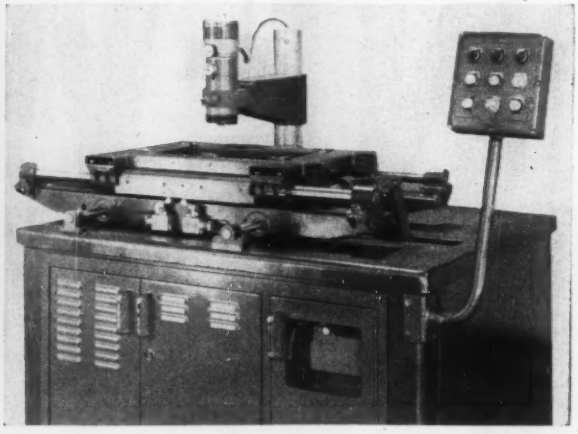
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter . . . Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on page 19



SPEEDS TO 120,000 RPM can be reached by the spindle of this new internal precision cylindrical grinder introduced by Aaron Machinery Co. Inc. Different speeds can be selected electrically for the grinding head and the workhead. Grinding table has uniform speed of stroke in stroke lengths from 0.004 to 4¾ in. Infeed of the grinding wheel is automatic and adjustable from 0.00002-in. per stroke. Accessories automate control of work spindle, longitudinal travel, cross-feed speed.



DIGITAL POSITIONING, by Laboratory for Electronics Inc., enables automatic positioning by this drill press anywhere on a 1/64-in. grid in an area 8 by 16 in. Holes are drilled at the rate of one per second. Machine control is punched tape. All dimensions are read from a common reference, thereby avoiding accumulated errors. System can be applied to other machines and a decimal grid of 0.001-in. can be specified.

(*Continued from Page* 15)

cause "the regenerator is inherently self-cleaning and the exhaust gases are soot free."

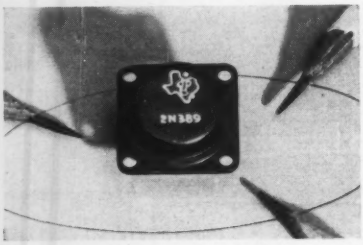
"High speed rotating parts, compressor and turbines, have stood up well although the turbine engine has no air cleaners. The present life of combustion chamber liners appears to be less than desirable and work is continuing in this area."

Engine maintenance and spare parts problems will be simplified in commercial vehicles.

The engineers admitted the problem of manufacturing costs "still remains unresolved largely because engines of this type have not been built in quantity using automotive production techniques."

However, they said, a gas turbine engine consists mainly of simple castings and stampings that call for no new manufacturing methods. The exception is the fabrication of turbine wheels which "pose an exceptionally difficult problem and will require special attention."

Substantial quantities of high-temperature alloys have been required in the hot areas of the engine. These requirements, however, will yield to development.



HIGHEST POWER SILICON TRANSISTOR—also the first commercial gaseous diffused-junction transistor—now enables high-temperature operation of high-power servo and audio output systems. Introduced by Texas Instruments Inc., the unit has a rated power dissipation of 37.5 w at 25 C and 15 w at 100 C. Operating temperature limits are −65 C and 150 C.

"It is reasonable to assume that production in quantity should bring manufacturing costs of the turbine engine to the same general level as that of high output piston engines, especially when the overall installed power plant is considered."

Experience indicates that the gas turbine should be an ideal engine for heavy-duty vehicles.

Industrial Designers Cite Best 1957 Products, Creators

Designs in Three Fields Tendered Equal Merit

CHICAGO, ILL. — Design teams in the fields of transportation, electronics and housewares have been named recipients of the 7th Annual Design Awards sponsored by the Industrial Designers' Institute. The awards are medals, all of equal merit, and constitute recognition for outstanding creative work in industry.

The design teams honored this year are:

Arthur N. Becvar and Robert W. Blee, "for their design of the General Electric Kitchen Center, a coordinated assembly of kitchen appliances, pre-wired and pre-plumbed for minimum installation time."

Virgil M. Exner, Henry T. King, H. T. Bannister, C. C. Voss, Carl Reynolds, and Robert Bingman, "for their establishment of a continuity of design which reflects with distinction the spirit of the 1957 Chrysler Corp. cars, while maintaining a separate design identity for each of the individual

ARISTOLOY STEELS

LEADED STEELS LATEST INFORMATION

New 16-page booklet presents latest information on basic characteristics, mechanical properties and workability of Aristoloy Leaded Steels. Test results are supported by complete data and charts. Also contains several pages of case histories based on manufacturers' experience and documented by time study records, showing actual savings in reduced machining time and increased tool life.

COPPERWELD STEEL COMPANY
STEEL DIVISION
4017 Mahoning Avenue • Warren, Ohio
EXPORT: Copperweld Steel International Co.
225 Broadway, New York 7, N. Y.

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Circle 414 on page 19

car divisions."

Carl W. Sundberg, Montgomery Ferar, R. W. Figgins, U. J. Pepin, H. F. Weber and Eliot Noyes, "for the design of the IBM Ramac, and for imparting an architectural quality which will integrate well with contemporary office design."

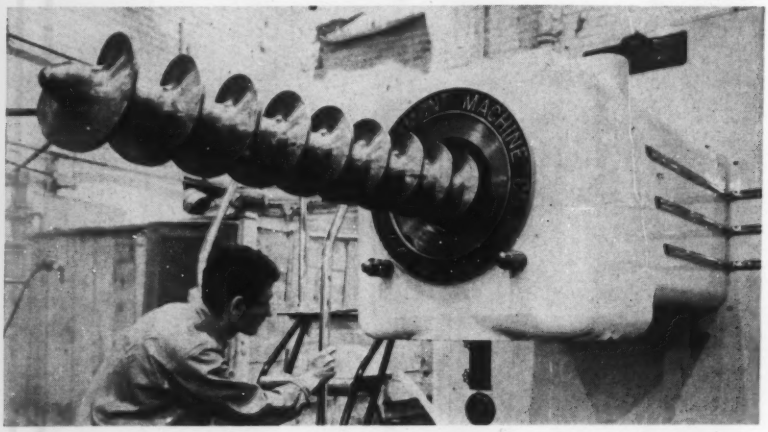
Solar Cells May Power Satellite Instruments

Successfully Tested on Rocket 190 Miles Up

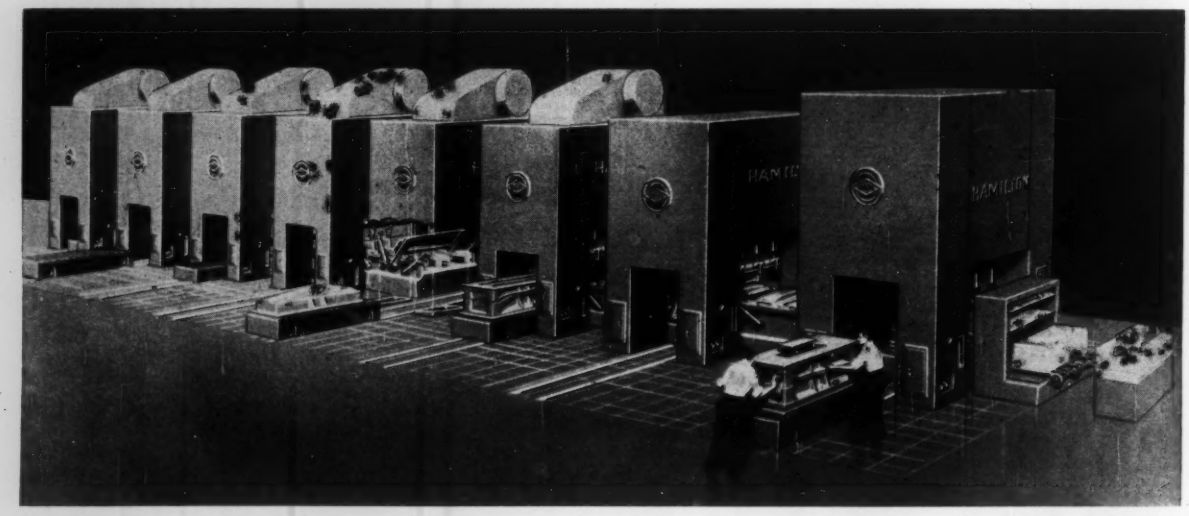
WASHINGTON, D.C.—Energy from the sun may power the instruments in the earth satellite, according to a recent announcement from the Dept. of Defense. Engineers at the Army Signal Corps Laboratories have found that solar batteries consisting of tiny silicon wafers may be the ideal power source.

To test this theory, glass-protected clusters of solar cells were attached to the skin of an Aerobee-Hi rocket. When the rocket was fired to an altitude of 190 miles—approximate satellite altitude—the batteries functioned perfectly. Interpretation of data telemetered back to the earth indicated that the cells provided continuous electrical output from the time of the firing until the rocket's radio ceased functioning on re-entering dense atmosphere.

Electrical output varied only slightly, depending on the batteries' exposure to various degrees of direct or reflected sunlight. The cells were not affected by the high tem-



HELIX CAST IN STAINLESS, all in one piece, replaces similar built-up part made from carbon steel stock elements. Cast by Empire Steel Castings Inc., the screw is part of a vacuumized macaroni press by Clermont Machine Co. Stainless satisfied the need for cleanliness in a food machine. Casting method enabled design changes in the screw which enable higher process speeds, reduce product spoilage due to scorching. The screw is 60 in. long, 6 in. in diam. Cored hole through shaft serves as cooling water channel.



LESS DIE CHANGE TIME is the result of this design for short-run production presses by Hamilton Div. of Baldwin-Lima-Hamilton Corp. Die and punch pairs are mounted on bolsters which slide into place through the sides of presses when dies are changed. Each press has two bolsters, motor driven and actuated independently or together from controls in the press base. To change a die, press is run to bottom of stroke, punch is freed from slide, slide is moved up, new bolster is run in while old is run out, slide is lowered to receive new punch, shut height is adjusted and new run begins. Operation take ½-hr, 75 per cent less time than before.

How to detect and measure flange bending in gasketed joints

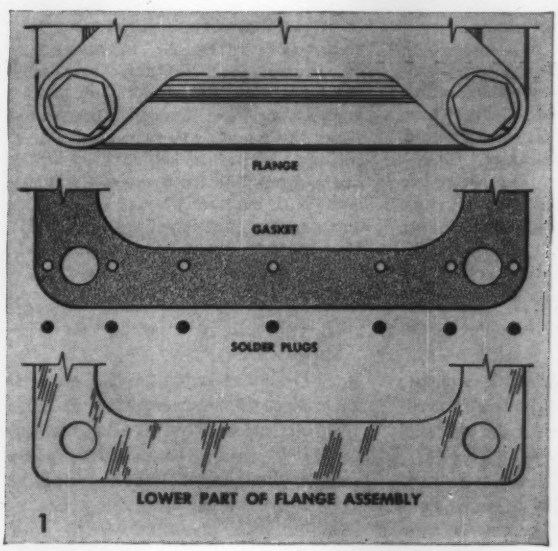
A surprisingly large percentage of gasket leaks is caused by almost undetectable bending or bowing that occurs between flange bolts, according to tests conducted at the Armstrong Research and Development Center.

Obviously, bending is most likely to be found where flanges are light, where bolts are widely spaced, or where bolting pressure is high. But it can also occur in heavy flanges, where bolts are not properly spaced.

Flange bending can cause leaks because it reduces the flange pressure on a gasket in the area midway between bolt holes and thus reduces gasket compression. Also, it may cause extrusion of the gasket near the bolts because of the concentrated pressure in these areas.

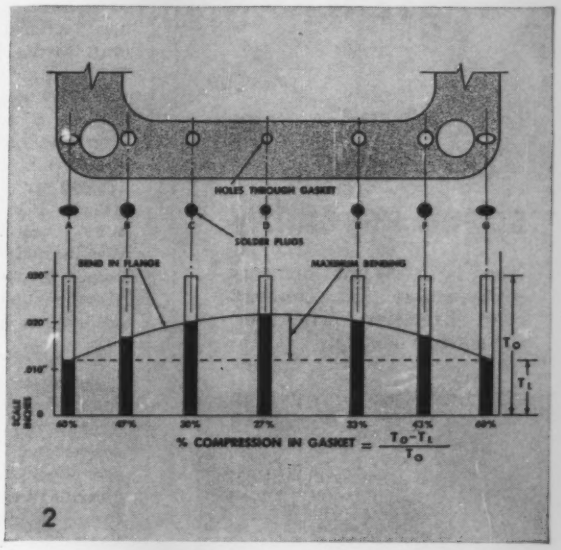
There are three qualitative ways and one quantitative way that an engineer can determine if flange bending is taking place.

1) *Pinpoint the leakage.* If leaks originate at center points between bolts, there's good reason to believe that flange bending is the source of trouble.
2) *Look for localized extrusion.* Extrusion near bolts—and not at midway points—indicates that flange bending is present.
3) *Check for varying gasket adhesion.* Flange pressure is one of the factors causing gasket adhesion. Consequently, where pressure is greatest, greatest adhesion should occur. If upon opening a leaky joint the gasket is found to be sticking more around bolts than at center, flange bending probably is occurring.



TO QUANTITATIVELY MEASURE FLANGE PRESSURE or gasket compression at any particular point, a simple yet accurate "solder plug" test devised by Armstrong research engineers can be used.

Drill several holes about 1/32 inch in diameter through thickness of gasket to be tested. Insert in these holes cylinders or plugs of soft solder. (Fig. 1) The plugs should be thick enough so that when the flanges compress the gasket, the plugs will also be compressed. Put gasket with solder plugs into flange and tighten bolts to desired torque.



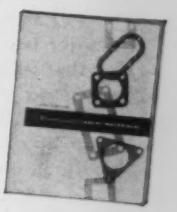
Open the flange and measure thickness of solder plugs. Each plug obviously will measure exactly the same as the compressed thickness of the gasket at the point where it was located.

The extent of flange bending can be shown graphically by charting the solder plug thicknesses. (Fig. 2) If too much bending occurs, gasket will be overcompressed around bolts and undercompressed between bolts.

The percentage of compression can be easily calculated by using the formula in Figure 2. With this information, it is possible to determine whether the gasket material is within its recommended range at specific locations on the flange. The load-compression curves for the gasket material in question may be used to estimate unit loads. But these are relative unit loads and not absolute values. In addition, picking unit loads from load compression curves is applicable only to the compressible gasket materials such as cork composition.

SEND FOR 1957 EDITION OF "ARMSTRONG GASKET MATERIALS"

This 16-page booklet discusses the choice of proper gasket materials and describes Armstrong cork, cork-and-rubber, synthetic rubber, and fiber sheet materials. Included are government and SAE-ASTM specifications. Look for this booklet in Sweet's product design file. Or for a personal copy, write Armstrong Cork Company, Industrial Division, 7207 Dean St., Lancaster, Penna.



Armstrong

GASKET MATERIALS

. . . used wherever performance counts

Circle 415 on page 19

PEM
WELD
FASTENERS

cut costs...
speed assembly

Now in steel and non-corrosive, non-magnetic stainless steel. Exclusive cost-cutting advantages include:

1 Engineered projections. No burn outs on thin sheets. Simple electrodes. No pilots needed.
2 Self-locating, shank protects threads from weld splatter. No retapping.
3 Round shape. No indexing. Compact for use on narrow flanges.

Write for literature and samples for trial. Prove to yourself that PEM Weld Fasteners will speed your assembly and cut equipment and labor costs while doing a better fastening job. Penn Engineering & Manufacturing Corp., Doylestown, Pa.

PEM

Circle 416 on page 19

Defense Digest

Prop-jets plus turbo-jets will power a new radar picket plane to be built for the Navy by Lockheed Aircraft Corp. The new craft will resemble Lockheed's 1649A Starliner, but will carry powerful new search tracking radar in a saucer-shaped radome atop the airplane's fuselage. It will have a gross weight of approx. 175,000 lb. In addition to four Allison T-56 prop-jet engines, the W2V-1 will be equipped with two Westinghouse J-34 turbojets, attached in wingtip pods, which will provide supplementary power for cruising at higher altitudes.

• • •

Televised test firings of rocket engines is a new procedure at Rocketdyne Division of North American Aviation. Cameras are shock-shielded on permanent mounts and remotely controlled from concrete recording centers located several hundred yards from the engine test stands. Mounted at 120-degree angles from the stands, the TV cameras monitor test firings at close focus. Use of Zoomar lenses allows engineers to watch for propellant leaks or other possible malfunctions as the firing progresses. The engines are mounted on steel and concrete test stands built to withstand 1 million lb of thrust.

• • •

Advanced missile antennas and radar devices will be designed and tested in new facilities being built at Lockheed Aircraft Corp. They will aid studies in improving radio and radar transmission and reception from extremely high altitudes and under severe operating conditions. Building plans include an anechoic chamber measuring 20 by 70 ft, specially constructed to eliminate radio reflections during precision measurement of radio frequency signals, and a dielectrometer room to be used for measurement of electromagnetic properties of various metals. The buildings and instrumentation have been designed for pushbutton, automatic procedures.

Research will be directed toward impedance and pattern measurements, determination of reflection characteristics of radar targets and enhancement devices, experimental studies of ionospheric and tropospheric propagation, measurements of radome transmission and reflection characteristics, and microwave measurements of special materials.

• • •

High speed torpedo, its fire control system, and related components will be developed for the Navy by Westinghouse Electric Corp. The weapon is to be capable of destroying submarines as well as surface vessels.

• • •

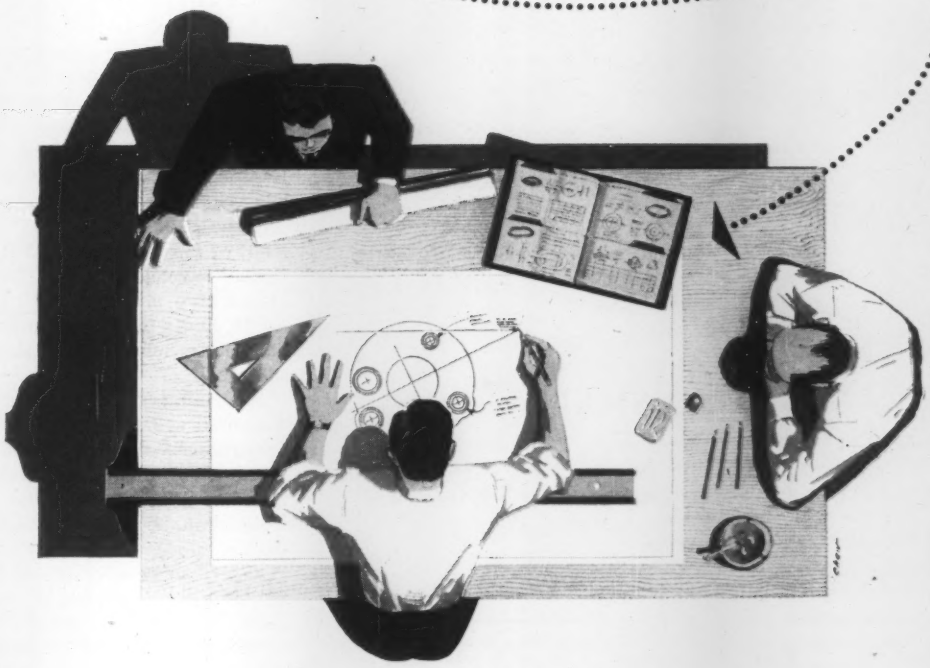
New type of landing gear for heavy Air Force cargo planes with a gross weight to 100,000 lb, has been developed by Lockheed Aircraft Corp. Instead of the conventional arrangement, the new device features two wheels, one in front of another, as on a bicycle. Mounted on each side of the aircraft, this tandem arrangement is claimed to offer the advantages of improved reliability, smaller concentration of weight on the runway and a narrower housing when the wheels are retracted. For military airplanes which may operate from hastily prepared fields with soft surface of dirt or sand, the tandem arrangement permits the second wheel to run in the tightly packed track of the first, thereby reducing friction.

perature of skin friction as the rocket passed through the atmosphere at more than a mile per second.

The Navy has disclosed that tests on the suitability of solar cells for use as the primary power supply within the satellite will be continued during some of the early launchings. The tests will include long-time exposure to the environmental conditions existing at satellite altitudes. Solar cells are particularly suited to satellite power supply because of their comparative light weight and long life.

Solar cells attached to the satellite skin would supply instrument power during approximately 60 of each 100 minutes during which the

. . . good sealing begins here, too!



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Circle 417 on page 19

NEW
HEAVY DUTY
multiple circuit switch for machine tools

ACRO "DUO-SNAP"

HIGH ELECTRICAL RATING—2 horsepower, 230 volts A.C./1 horsepower, 115 volts A.C./ pilot duty, 20 amps, 250 volts A.C.

LONG LIFE—Many millions of cycles mechanical life. Consult factory for maximum electrical life.

SCREW TERMINALS—Easy installation.

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AVAILABLE TYPES		
Catalogue No.	**Circuit Arrangement**	**No. of Terminals**
242-0004-03	Four Circuits 2 Closed 2 Open	8
242-0005-03	Double Circuit 1 Closed 1 Open	4
242-0013-03	Double Circuit Normally Closed	4
242-0014-03	Double Circuit Normally Open	4

The famous ACRO rolling spring principle assures positive snap action in this multiple circuit switch developed especially for rugged service in the machine tool industry. Get full information on it now. Write for the new "Duo-Snap" Switch Bulletin.

Mr. Controls®

Robertshaw-Fulton
CONTROLS COMPANY

ACRO DIVISION • Columbus 16, Ohio

Circle 418 on page 19

News Roundup

vehicle is in the sun on each circuit of the earth. The batteries also could charge small nickel-cadmium batteries to provide electricity during the remaining 40 minutes that the satellite would be travelling in the earth's shadow.

Crystal-Ball Engineering Forecasts Needed Arms

Weapon Systems Analysis Can Cue Designers

BUFFALO, N. Y. — Continuous increase in the complexity and variety of modern weapons has brought into being a new technical specialty called Weapons System Research. Engineers in the new field have the job of second-guessing ahead of time on the development of new weapons and the creation of defense systems. This kind of research is summarized by Robert H. Shatz in a recent publication of the Cornell Aeronautical Laboratory.

According to the summary, a weapons system analyst and an operations research analyst draw upon a common technical background and have similar objectives, but the weapons specialist works more in the future. He "tries to answer questions related to future development requirements and force structure."

"Systems analysts can assist the designer in three important areas: in the selection of weapons systems characteristics, based on total mission capability; in critical comparisons with competing systems; and in program p'anning.

"The systems analyst will be cold-blooded in assessing the merits of the home team's inventions, and can help the design team's management to establish sound goals which will stand up for long periods of time. In many cases the systems analyst will uncover why a particular weapons system is not satisfactory; thus the research and development effort needed for improvement of the system can be planned more concretely.

"Experience to date on results and how they stand up to the final

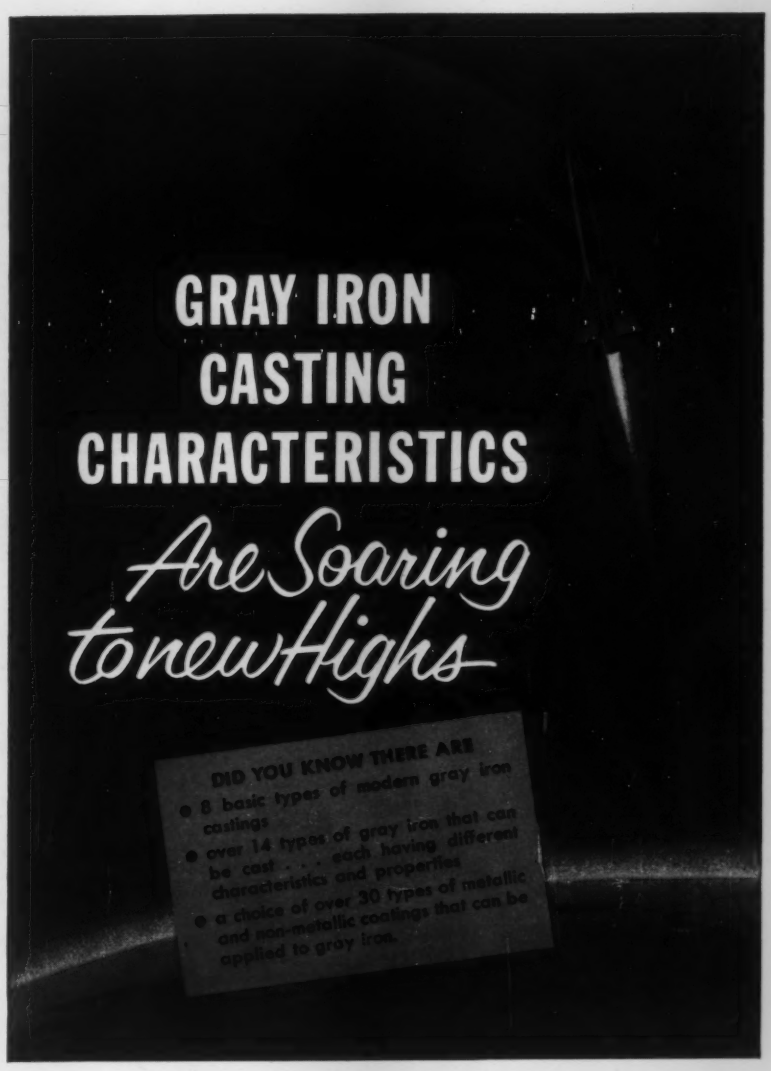
SMALLEST TURBOSHAFT AIRCRAFT ENGINE ever built will power one-man helicopter. Weighing 50 lb, the new gas turbine will produce 55 shp plus 12 lb thrust on a hot 100 F day. Engine rotor spins at 57,600 rpm. Designed for Army and Navy by Solar Aircraft Co., the engine is 20 in. high, has maximum diameter of 15½ in.

test of time has been mixed. However, two things are quite clear. The attempts made by the analyst to provide quantitative answers to these difficult problems have been well worthwhile, and the answers have been better than those provided by any other approach.

"Current work in this field must be improved, and can be, by the establishment of general solutions to such basic problems as the effect of countermeasures on weapons systems performance, the effect of morale in military organizations, and the quantitative assessment of complex command-control system performance."

Bearing problems, such as those encountered with high speed, high load and high temperatures, are sought by the Continental Bearing Research Corp., 489 Fifth Ave., New York, N. Y. This company was formed recently to provide engineering development and manufacturing in the field of bearings and lubrication. The firm's stated objective is to analyze, design and

(*Continued on Page* 32)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DID YOU KNOW THERE ARE
• 8 basic types of modern gray iron castings
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If you are on the lookout for new ways and means to improve your products *and save money, too,* investigate modern gray iron castings. Gray iron is not only the most economical of all basic components, but recent developments in new gray irons and casting techniques are elevating their utility to new highs. Today they possess a combination of essential engineering properties that cannot normally be duplicated in more expensive competitive materials. Acquaint yourself with the present and future possibilities of modern, controlled gray irons. Be sure that gray iron is making its full contribution to your products. Write for the GIFS "Summary of Specifications" today.

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National City-East 6th Bldg. • Cleveland 14, Ohio

Circle 419 on page 19

NOW! A Small Machine That Makes Big Prints . . . New Model 300!

It's only 46" wide, yet offers a full 30" printing width! This remarkable low-priced table top machine brings "inside" reproduction within the means of the smallest department or firm, makes an ideal "extra" machine for large companies. Handles every type of reproduction job that bigger, costlier machines do. Operates on 115 volt A.C.

Right Now Is the Time to New and Better Copyflex

NOW! A Faster, Easier-to-Use, Heavy-Volume Machine . . . Model 500!

You'll turn out more work with less operator time and effort with this new, ultra-fast machine. It offers top mechanical speed of 40 f.p.m., 46" printing width, automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features. Its 4,000-watt quartz lamp and synchronized exposure and developer units assure uniformly sharp, clear prints.

Act Now to Save Time and Manpower, Meet Growing Production Boom Demands!

Now is the time to take a good look at your older reproduction equipment. If it's more than a few years old, chances are it's costing you unnecessary time and money. It may well turn out to be a bottleneck in your efforts to meet growing production boom demands.

Compare your equipment with the new, modern Bruning machines shown here. You should be getting the time and manpower savings offered by greater mechanical speeds, faster return of originals, automatic separation, front or rear delivery! You should be benefiting by problem-free installation and operation—no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

If you're not getting these important advantages, then every day you delay getting new, modern Copyflex is costing you time and money. Act now by mailing the coupon below. You'll be glad you did!

NOW! The Speedy, Versatile Helper Your Big Machine Needs . . . New Model 110!

When you need prints of such smaller size originals as specification sheets, check prints, and engineering changes, this handy table top machine turns them out in a jiffy without tying up your big machine. It saves you time, money, and inconvenience. It has a printing width of 11". Makes 8½ x 11 prints for less than 1¢ each for materials. Operates on 115 volt A.C.

Replace Old Equipment with Reproduction Machines!

NOW! A Space-Saving, Versatile Big-Volume Machine . . . Model 250!

It takes less than a square yard of floor space, yet offers a printing width of 18½" and a fast mechanical speed of 25 f.p.m. Automatic separation and stacking, one-knob control, and an extra-large feed board simplify and speed operator's work. Operates on 220 volt A.C.

NOW! A Budget-Priced, Heavy-Volume Machine . . . New Model 35!

This low-cost machine gives you all the advantages of big volume savings and speed. It provides a full 46" printing width and up to 30 f.p.m. mechanical speed. One knob controls exposure and development, assures consistently top quality prints. Handles roll stock up to 42" wide quickly and efficiently. Operates on 220 volt A.C.

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Best Selection of Materials!

Offices in 38 Cities of the U. S. and Canada

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In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

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Please send me information on the Copyflex process and the following machines: _____

Name _____ **Title** _____

Company _____

Address _____

City _____ **County** _____ **State** _____

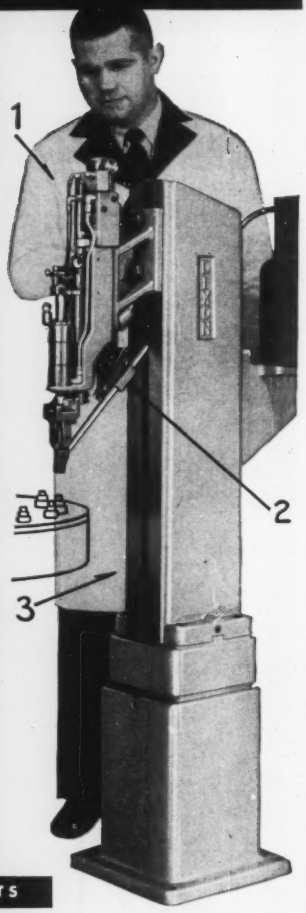
Circle 420 on page 19

Announcing New Standard DIXON "Auto-Positioner"

SIMPLIFIES SMALL PARTS ASSEMBLY OPERATIONS

AUTOMATICALLY GUIDES PARTS OF 1/16" TO 3" O.D. SIZE AT RATES UP TO 7200 PER HOUR

The new Dixon "Auto-Positioner" combines three standardized units — (1) Escapement, (2) Automatic Positioner, and (3) Mounting Structure — and now provides an economical solution for automating small parts assembly operations. "Auto-Positioners" are easily arranged at single or multiple stations with fixtures, feeders, feed tracks, transfer or indexing tables. The positioner, properly tooled with a proven feeder, can place parts at rates up to 7200 pieces per hour. Full electrical controls are included with provisions for automatic interlocking.



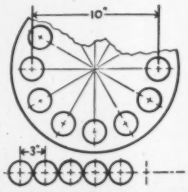
FEATURES OF STANDARDIZED UNITS

1-DIXON PARTS POSITIONER—a compact, self-contained air-operated automatic cycling unit with exclusive built-in sensing features. Automatically stops your machines when parts are missing or malformed. Handles parts of 1/16" up to 3" O.D. size. Engineered for mounting individual chuck jaws to suit varied requirements. Four standard models available with 1", 2", 3", 4" strokes.

2-DIXON PARTS ESCAPEMENT—Automatically releases single parts or in multiples at speeds up to 200 piece-parts per minute. Blank rear finger is easily shaped to suit piece-part. Standard models available for air, solenoid, or mechanical operation.

3-DIXON MACHINE STRUCTURE—includes rugged semi-steel column with machined T-slots, sturdy base, and spacer blocks to suit varied locating and operating requirements. Compactly designed to fit in small space. Special support brackets available for feeders, work tables, etc.

INDIVIDUAL UNITS OR ANY COMBINATION OF STANDARD COMPONENTS AVAILABLE FROM STOCK. TOOLED "AUTO-POSITIONERS" PROVIDED TO SUIT NEEDS.



May be located at adjacent stations, only 3" apart for straight-line indexing, or on 12-station dial with a 5" fixture radius.

DIXON

WRITE FOR FREE DATA SHEETS
New bulletins supply specifications and application data on standardized units now available from stock.

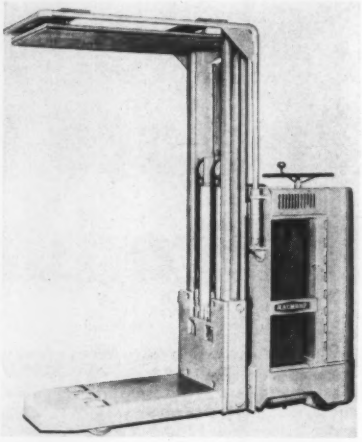
DIXON AUTOMATIC TOOL, INC.
2310 – 23RD AVENUE ● ROCKFORD, ILLINOIS
AUTOMATIC PARTS HANDLING AND ASSEMBLY EQUIPMENT

News Roundup

(*Continued from Page* 29)

supply bearings in production or semiproduction quantities for specific applications. Design studies are undertaken on a project or consulting basis.

The company has designed bearings that operate with low-viscosity lubricants such as air and water in water pumps and gas turbines.



LOAD STABILIZER ATTACHMENT designed by Raymond Corporation for use on their narrow aisle platform trucks, permits speedy, safe lateral movement of tall, unstable loads. Flat pressure plate which contacts top of load is rubber faced and supported by a spring arrangement at each corner. Platform of truck elevates load until top of the load touches pressure plate. A limit switch automatically shuts off the lift pump when enough pressure is exerted against plate to hold the load securely.

American Society for Testing Materials has elected Richard T. Kropf president for the forthcoming year. Mr. Kropf is vice president and director of research of Belding Heminway Co. Inc., New York, also directs the activities of the Industrial Thread Div., and serves as general manager of Belding Corticelli Industries Inc.

F. L. LaQue, vice president and manager of development and research for International Nickel Co. Inc., was elected ASTM vice president for a two-year term.

Prejudice Keeping Girls From Engineering Careers

Woman Engineer Claims Females Well Qualified

PITTSBURGH, PA.—Male advantage in basic engineering aptitude tests is just 3 to 2 over women, according to a 1956 report of U.S. Dept. of Labor. Yet, of more than 120,000 women who received degrees in 1956, only 62 were graduated in engineering.

Putting these facts together, Emma C. Barth, turbine generator engineer at Westinghouse Corp., states that "prejudices and misunderstandings are keeping girls out of a profession labeled as masculine."

According to Miss Barth, "basic requirements for engineering include mental capacity, enjoyment of mathematics and science and the ability to visualize and make prompt decisions. None of these abilities pertain to sex." More important, "an engineer must be able to handle people." In this respect, Miss Barth suggests that women are better suited to engineering than men because they instinctively know more about dealing with people.

Tendency among counselors in engineering is to suggest women as aides and assistants to engineers. Miss Barth condemns offering this type of work to girls with unusual records in mathematics and science. She suggests that the growing shortage of engineering manpower can be eased by womanpower if industry and education make proper adjustments.

Vidicon TV Camera Tube Registers Single Foot-Candle

HARRISON, N. J. — High effective sensitivity is the feature of a new 1-in. vidicon camera tube recently announced by RCA.

The new tube can be operated at signal-electrode voltages higher than those for any of RCA's current models. Operation at high voltages is made possible by the tube's uniform photosurface and

SOCKET CAP SCREWS

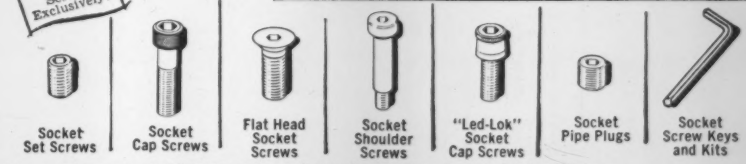
Here's the best advice we can give you, the right answer to the old problem of vibration. Blue Devil SAF-LOK Screws are available in a complete range of sizes from #6 to 1" for immediate delivery at your Blue Devil distributor. SAF-LOK is the only Socket Screw on the market today that is *absolutely* vibration-proof; an exclusive development of Safety Socket Screw Company.

ALSO SAF-LOK SHOULDER SCREWS AND FLAT HEAD SOCKET SCREWS

All three types give you an absolute seal against oil, water, gas and air as well as vibration.

Silver Anniversary 25 Years of Socket Screws Exclusively!

I'm Your Blue Devil Distributor
. . . and we can give you the story on this outstanding Blue Devil product, one of a complete line of socket screws. We have them on hand for immediate delivery. Call us today for any Blue Devil Socket Screw requirement.



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SAFETY SOCKET SCREW COMPANY
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Warehouses at: Los Angeles, San Francisco, Detroit, New Haven, Conn.

Circle 422 on page 19

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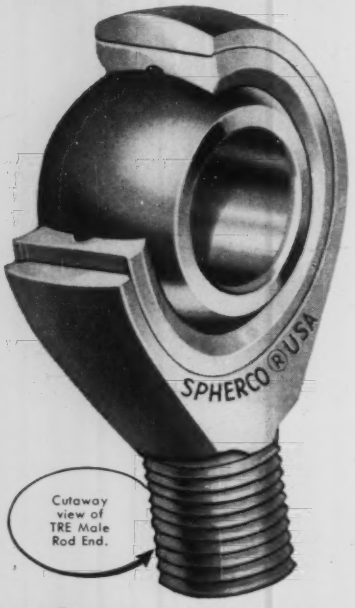
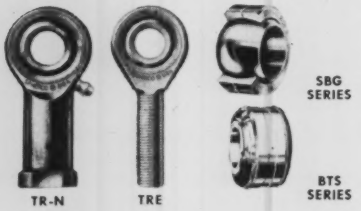
BEARINGS & ROD ENDS



Quality SPHERCO Bearings and Rod Ends are precision built for superior performance

There are SPHERCO Bearings and Rod Ends for every application! There is a SPHERCO Engineer in your area to help you with your problems.



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A PRODUCT OF
SEALMASTER BEARING DIVISION
STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.

Circle 423 on page 19

its extremely uniform dark current. Effect of the high voltage is a substantial increase in effective sensitivity.

Tests have shown that the new tube can produce a picture having a good signal-to-noise ratio and fast response to moving objects with as little as one foot-candle of highlight illumination on its faceplate.

ASME Announces New President, Secretary

The American Society of Mechanical Engineers has announced the nomination of James N. Landis as president for 1957-58. He will be installed during the society's annual meeting in December. Mr. Landis is vice president of Bechtel Corp., San Francisco. He has served as a chairman of both the San Francisco Section and the New York Metropolitan Section.

James N. Landis

Oscar B. Schier II has been named secretary-elect of ASME. He succeeds Clarence E. Davies, who will retire after 23 years as secretary. Mr. Schier joined ASME in 1932 and has been a member of the staff for 11 years.

Largest ball valves for high pressure and high temperature have been produced by Hydromatics Inc. Intended for use in systems operating at pressures to 2000 psi and temperatures to 225

Metals Matters

High-strength steel that can be heat treated to a strength of 285,000 psi with sufficient ductility for structural applications has been developed by the National Bureau of Standards. The steel is made by normal melting and working processes and should not be difficult to manufacture, according to NBS.

Mechanical Properties

Hardness (Rockwell C)	53
Ultimate tensile strength (psi)	285,000
Yield strength (psi)	235,000
Elongation, 1.4-in. gage-length (per cent)	10
Reduction in area (per cent)	35
Charpy (V-notch) impact strength:	
Room temperature (ft-lb)	16
−40 F (ft-lb)	16

• • •

Current research at Lukens Steel Co. is directed toward the production of titanium, zirconium, and the Hastelloys in the form of clad steel plates. Potential applications of these clad steels are extensive, some of them involving processes of a classified nature, according to the company. In general, zirconium-clad would have a number of atomic applications, Hastelloy-clads could be utilized in various petrochemical processes, and titanium-clads would be applicable in acid processes and for service involving chlorides.

• • •

First zirconium vessel produced commercially by any fabricator is said to be this two gallon kettle displayed at a recent atomic energy exposition. Zirconium reaction vessels ranging up to 1000-gal capacity are in the planning stage, according to the Pfaudler Co., developers of this pilot plant model.

New From Du Pont

Cronaflex Engineering Reproduction Films

TRADEMARK

CRONAFLEX is a new line of photographic reproduction materials on Du Pont Cronar® polyester photographic film base. CRONAFLEX films are available in three types:

1. **DIRECT POSITIVE FILM** for making sharp black-line positives directly from pencil or ink drawings.
2. **CONTACT FILM** for negative "same-size" reproduction of originals for use in producing accurate positive intermediates.
3. **PROJECTION FILM** for use in cameras or enlargers to produce negative or positive copies.

CRONAFLEX is unbelievably rugged, absorbs a minimum amount of moisture and is the most dimensionally stable, tear-resistant reproduction film you can use. It resists kinking and will not shatter, tear, or become brittle with age. And, because CRONAFLEX dries so quickly, your intermediates can be ready for reproduction in 15 minutes or even less.

For those who insist on quality reproduction—engineers, draftsmen, blueprinters, cartographers, architects, surveyors—CRONAFLEX will more than fill your needs for long-lasting intermediates and duplicate originals. For more information on these new films, fill in the coupon.

E. I. du Pont de Nemours & Co. (Inc.) MD-7
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Please send me literature on CRONAFLEX.

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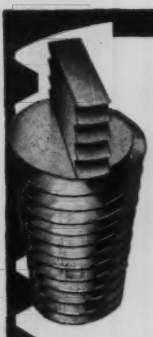
REG. U.S. PAT. OFF.
Better Things for Better Living
. . . through Chemistry

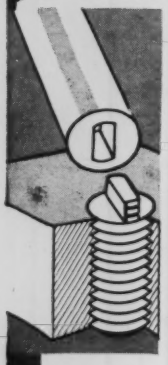
DU PONT CRONAFLEX for Functional Photography

Photography with a purpose . . . not an end in itself, but a means to an end.

Circle 424 on page 19



GREATER HOLDING POWER at LESS COST with Setko SLABBED HEAD Set Screws!



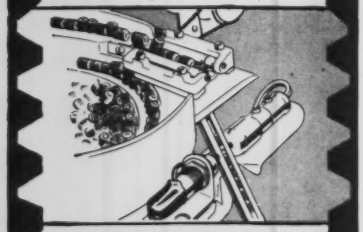
- *Will Take 50% more torque,* unique design resists damage.
- *Costs Less* than hexagon or fluted socket set screws.
- *Fully threaded.*
- *NU-CUP®* or standard points* available.
- *Can be Automated* with Setko's Hopper Feeding method.

*U. S. Pat. 2,778,265

Setko Slabbed Head Set Screws are real money savers. They cost less than comparable hexagon or fluted socket set screws, yet they take greater tightening pressures . . . Up to 50% more torque without damaging.

Holding power can be even further increased when furnished with Setko's own NU-CUP, the patented holding cup point that has a 42% sharper cutting angle. Cuts are deeper and in a full circle . . . With the extra pressure that can be exerted on the Slabbed Head Set Screw, NU-CUP really digs in tight.

Whether you drive them manually or with power . . . And whether your needs are large or small, *your costs will go down and holding power will go up.*



You Cut Costs Way Down When You Automate

Experience has proven that insertion rates of Slabbed Head Set Screws can be greatly increased when Automated by Setko's revolutionary Hopper Feeding System.

WRITE TODAY for full information . . . and ask for Catalog 21 which describes the complete Setko line of Set Screws.

Pat. No 2,638,945
Other Patents Pending

Set Screw & Mfg. Co.

157

28 Main Street, Bartlett, Illinois

Circle 425 on page 19

LARGEST TIRE MOLD is claimed for this 10,000-lb iron mold half made by Engineered Castings Div. of American Brake Shoe Co. With mating half, mold forms tires 8 ft in diameter for off-road equipment.

Pushbuttons and all other mechanical aids to safety, comfort and convenience are being demanded by 1957 car owners at a rate eclipsing all previous records, according to an owner survey just completed by Dodge Div., Chrysler Corp. Here are figures on equipment purchased with new Dodge cars since 1954.

Accessories	1954	1955	1956	1957*
Power steering	14.4%	20.0%	25.4%	45.6%
Power brakes	3.1	13.7	19.7	26.5
Radio	38.6	48.2	53.4	56.4
Heater	77.6	91.8	96.0	96.0
Air conditioning	0.5	0.6	0.4	2.8
Windshield washer	31.5	23.3	34.6	42.2
Backup lights	56.6	68.0	64.1	88.3
Glare-proof mirror	4.2	15.5	86.5	81.5
Whitewall tires	48.4	58.7	65.1	82.0
Automatic transmission	82.3	85.8	90.1	96.1

*Through May.

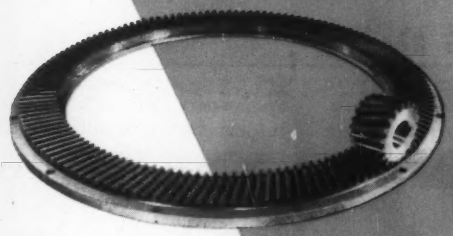
F, the 8-in. valves exhibit rapid response characteristics. They are capable of two full travel cycles per second or ten cycles per second through any one-tenth portion of a full stroke. The overall valve envelope is considerably smaller than any previous unit available for full-flow operation at pressures up to 2000 psi.

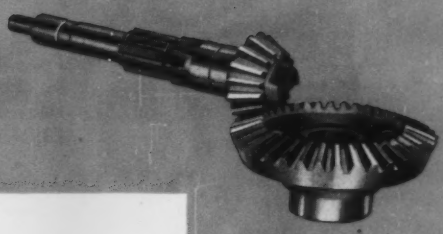
Meetings

AND EXPOSITIONS

August 11-15—

American Society of Mechanical Engineers. Heat Transfer Conference to be held at the Pennsylvania



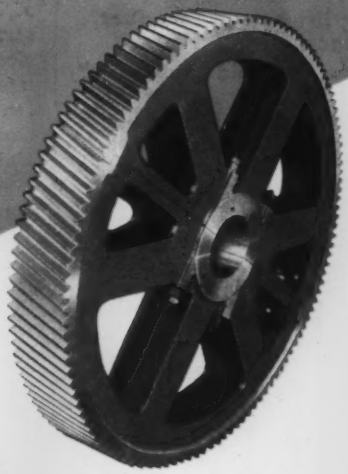


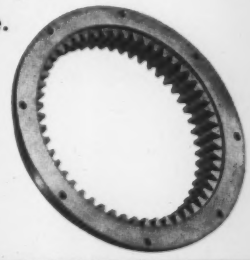
Quality with a pedigree

Every year more and more users of gears who demand the highest quality are turning to ILLINOIS GEAR to meet the exacting needs for this very important part of their equipment or machinery.

They have come to know and depend on ILLINOIS GEAR — a company with a rich heritage in the manufacture of quality gears . . . *from whose modern plants come the most complete line of gears in the world!*

If you use, specify or buy gears for any purpose — look to ILLINOIS GEAR as your most complete and dependable source.





Look for this mark ILG® *the symbol on finer gears*

ILLINOIS GEARS Reg. U.S. Pat. Off.

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

Circle 426 on page 19

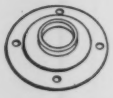
SPARTA
with our PATENTED PROCESS for Custom Molding in thin sections and shapes

NAMES MEAN A LOT - TOO!

TEFLON* with properties unmatched by any other material—

- simplifies new product designs
- helps solve old problems.

REMEMBER! If you want a custom molded part of Teflon that will work under severe service conditions and hold required tolerances . . . SPARTA'S patented process (No. 2,781,552) is your ONLY answer.



- Trained Fluorocarbon Engineers to assist you.
- Modern manufacturing methods for precision and quality.

WHEN YOU THINK OF TEFLON— . . . THINK OF SPARTA!

We carry a complete stock of all standard Teflon products.

WRITE for complete data, prices, properties and applications without cost or obligation. DEPT. MD

THE FIRST COST CAN BE THE LEAST . . . IF IT IS THE LAST COST.

*DuPont's tetrafluoroethylene resin.

SPARTA MANUFACTURING CO.
Division of United States Ceramic Tile Co.
DOVER, OHIO PHONE 4-2380

WESTERN DISTRICT OFFICE
Phone: ANGELUS 3-6359 · Los Angeles, California

Circle 427 on page 19

Engineering News Roundup

State University, University Park, Pa. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N.Y.

August 12-15—

Society of Automotive Engineers Inc. West Coast Meeting to be held at the Olympic Hotel, Seattle. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

August 20-23—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 342 N. La Brea, Los Angeles 36, Calif.

August 26-28—

Gas Dynamics Symposium to be held at the Technological Institute of Northwestern University. Sponsors are the American Rocket Society and the university. Further information can be obtained from Dr. Ali Bulent Cambel, Gas Dynamics Laboratory, Northwestern University, Evanston, Ill.

August 28-30—

American Institute of Electrical Engineers. Pacific General Meeting to be held in Pasco, Wash. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 4-6—

American Institute of Electrical Engineers. Magnetic Amplifiers Conference to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from institute headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-11—

American Institute of Electrical Engineers. Petroleum conference to be held at the Penn-Sheraton Hotel, Philadelphia. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-12—

Society of Automotive Engineers Inc. Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Sept. 9-13—

Instrument Society of America. 12th Annual Instrument-Automation Conference and Exhibit to be held in the Public Auditorium, Cleveland. Further information can be obtained from Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 17-20—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N.Y.

Sept. 23-25—

American Society of Mechanical Engineers. Fall Meeting to be held at Hotel Statler, Hartford, Conn. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 24-25—

Sixth Annual Industrial Electronics Symposium to be held at the Morrison Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from H. L. Garbarino, Armour Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 1-5—

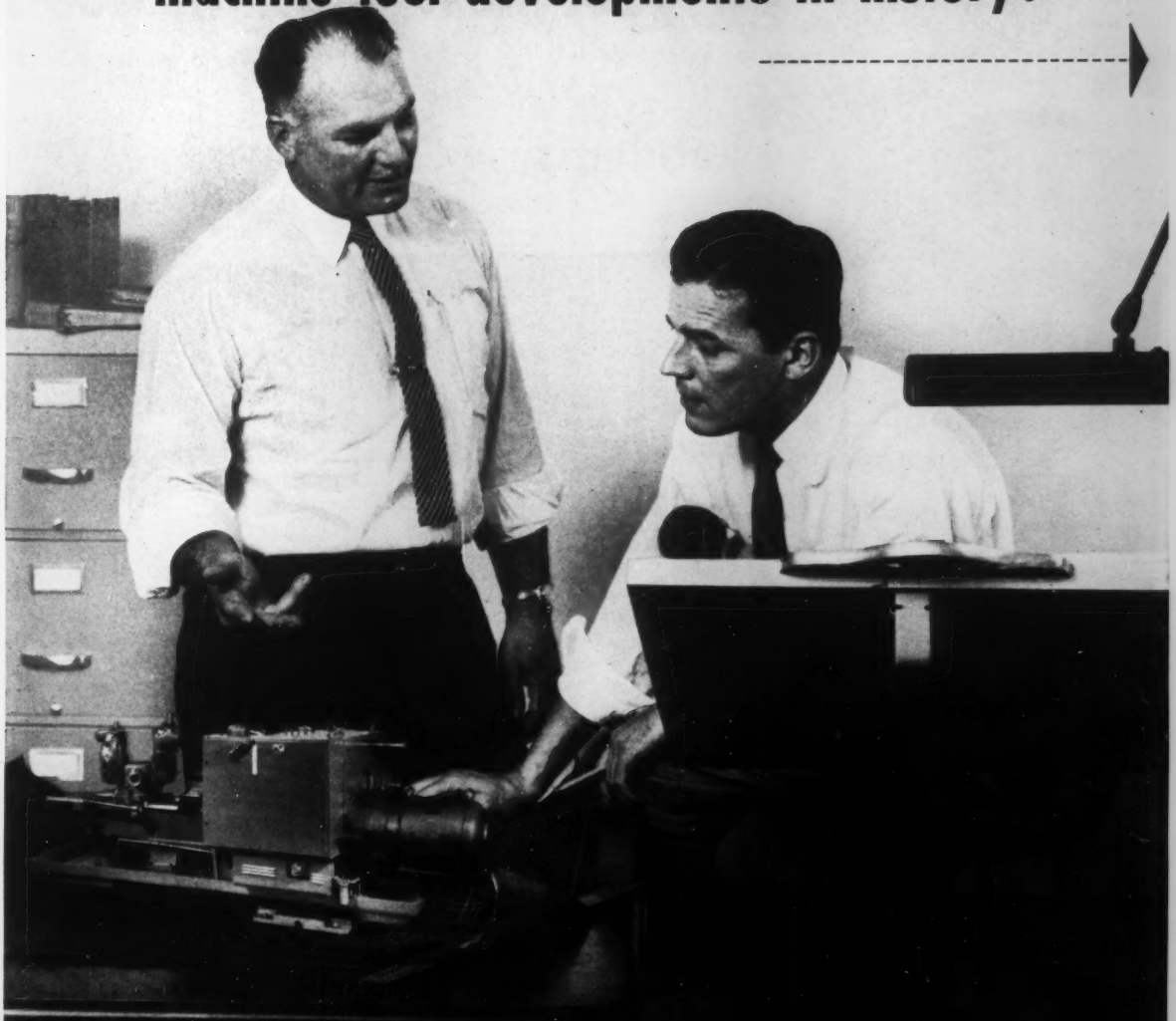
Society of Automotive Engineers Inc. Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N.Y.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

MACHINE TOOL DESIGNERS:

Westinghouse components and services will help you pioneer the greatest machine tool developments in history!



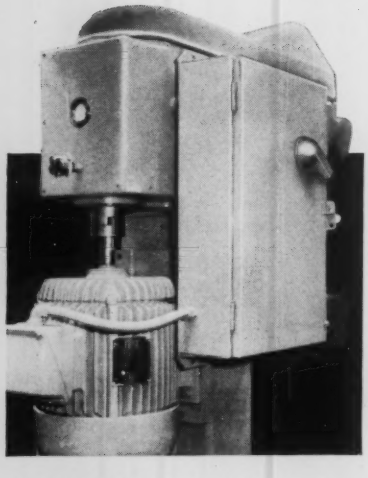
YOU CAN BE SURE... IF IT'S

Westinghouse

MP-3050-1

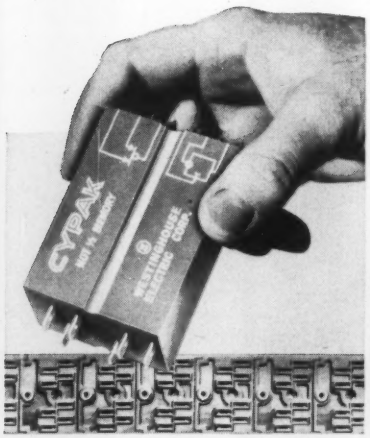
NEW DEVELOPMENTS FROM WESTINGHOUSE . . .

Improve drive and control functions on your new machine tools

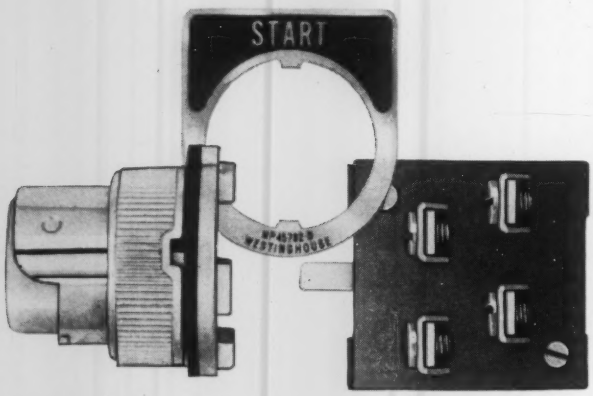


Eighty light-load reversals per minute and no overheating . . . with Westinghouse Life-Line® "A" motors. Reliable performance under severe duty cycles lets you plan greater versatility for machine tools.

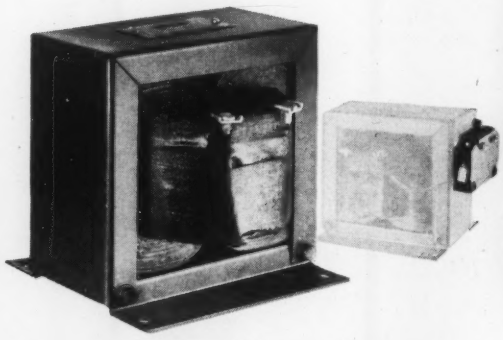
Cushioned start of connected load is assured by Westinghouse magnetic reduced-voltage starters. Add-A-Part feature provides flexibility for design and future change-over.



Cypak control has no moving parts to wear, corrode or jam. Service life is 15 times that of mechanical relays, maintenance and down time virtually eliminated. Cypak systems are compact, light, easy to modify.



Just 38 Westinghouse Oil-Tite* pushbutton components . . . standardized, interchangeable, always available from stock . . . offer up to 1,500,000 pushbutton control arrangements—cut space, inventory needs. *Trade-Mark



Westinghouse machine tool transformers take one-third less space, exceed NEMA regulation standards by 30%. Add-A-Part fuse blocks and breakers extend design selection, reduce transformer inventories.

The growing trend to faster specialized machine tools with more automatic operation makes design of compact, dependable drive and control systems for your products more vital than ever. Westinghouse has recently contributed many significant electrical developments to machinery builders that promise great strides in machine tool progress.

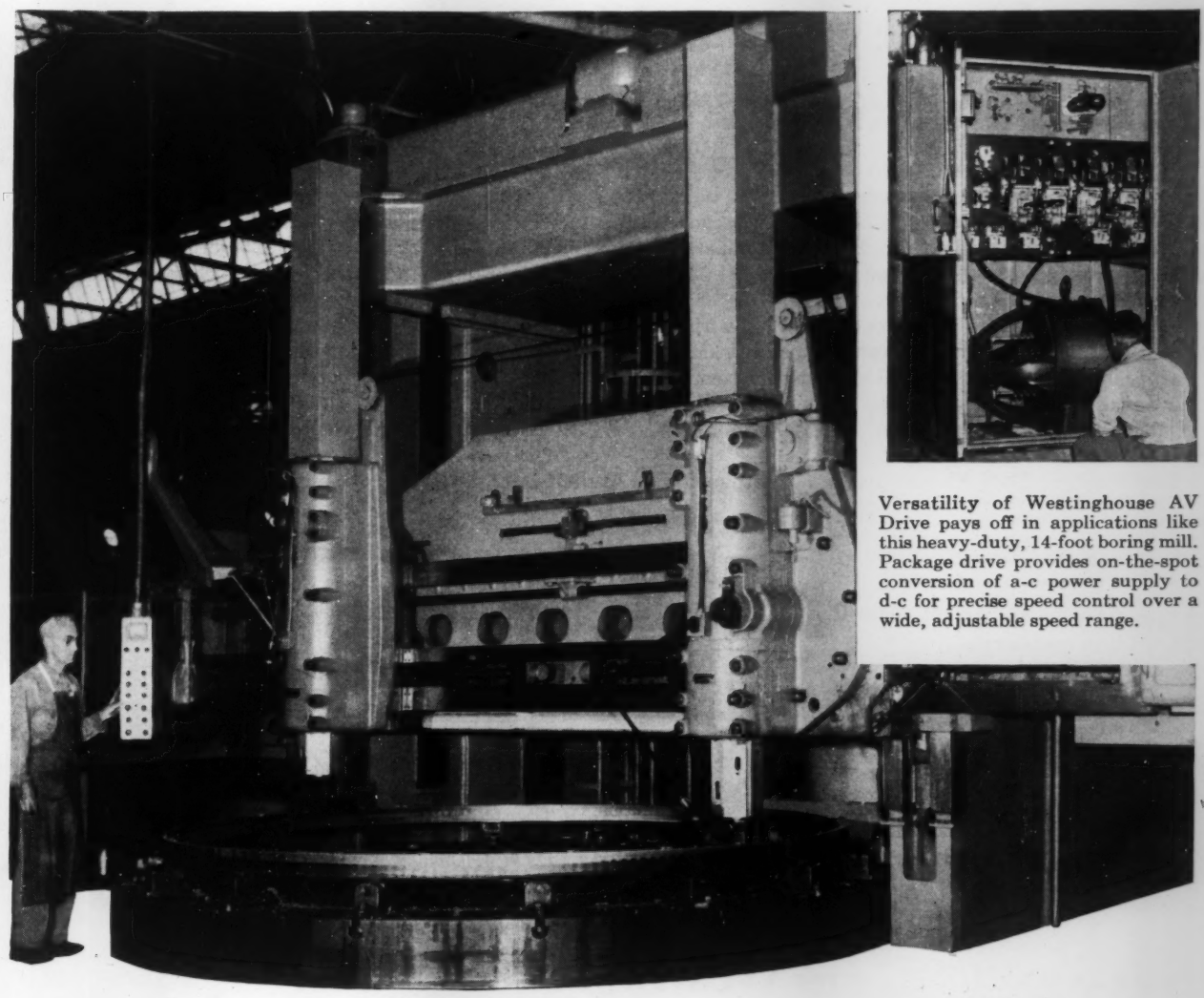
For example, there's Cypak*, a revolutionary development of Westinghouse research for reliable electrical control for machine operations, processes, and coordinated handling of materials. *It has no moving parts* to wear, corrode or jam . . . assuring long life and dependability.

Contactless limit switches, industrial electronic components unsurpassed in performance, improved-design motors, and numerous other product refinements and innovations point to Westinghouse as the electric components supplier for your machine tools.

Developments like these will help you design and build machine tools that better satisfy your customers through increased productivity, reduced inspection and maintenance, and more precise operation. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control, or driving . . . think of Westinghouse components first.

*Trade-Mark
MP-3050-2

YOU CAN BE SURE... IF IT'S Westinghouse



Versatility of Westinghouse AV Drive pays off in applications like this heavy-duty, 14-foot boring mill. Package drive provides on-the-spot conversion of a-c power supply to d-c for precise speed control over a wide, adjustable speed range.

Westinghouse service and facilities back up product performance

Your local Westinghouse representative should be a member of your machine design team. He is trained to give you the full benefit of Westinghouse engineering and development information in analyzing your machinery electrification problems.

Westinghouse facilities are located in industrial centers from coast to coast. Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . all have been established to benefit you and your customers.

The Machine Tool Electrification Forum, sponsored annually by Westinghouse during the past 21 years, is an example of Westinghouse participation and cooperation with the machine tool industry. New ideas fostered and exchanged at such meetings help speed machine tool advances.

When you specify components, choose Westinghouse and be *sure*. You get one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. And, Westinghouse components help sell your products. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

MP-3050-3

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak
- Magamp* magnetic amplifiers—rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

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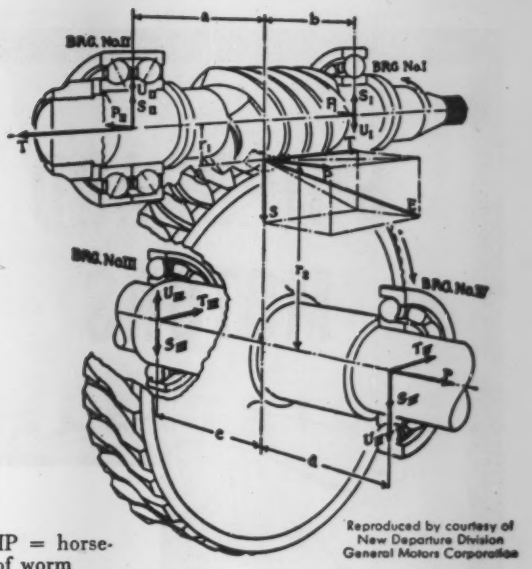
Circle 428 on page 19

(Advertisement)

Helpful Data from DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \frac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \frac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches

[r_2 = Pitch radius of worm gear

$= \frac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \frac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \frac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \frac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \frac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \frac{a}{a+b} = P_I$	$P \frac{b}{a+b} = P_{II}$
S	$S \frac{a}{a+b} = S_I$	$S \frac{b}{a+b} = S_{II}$
T	$T \frac{r_1}{a+b} = U_I$	$T \frac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \frac{r_2}{c+d} = U_{III}$	$P \frac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \frac{d}{c+d} = S_{III}$	$S \frac{c}{c+d} = S_{IV}$
T	$T \frac{d}{c+d} = T_{III}$	$T \frac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

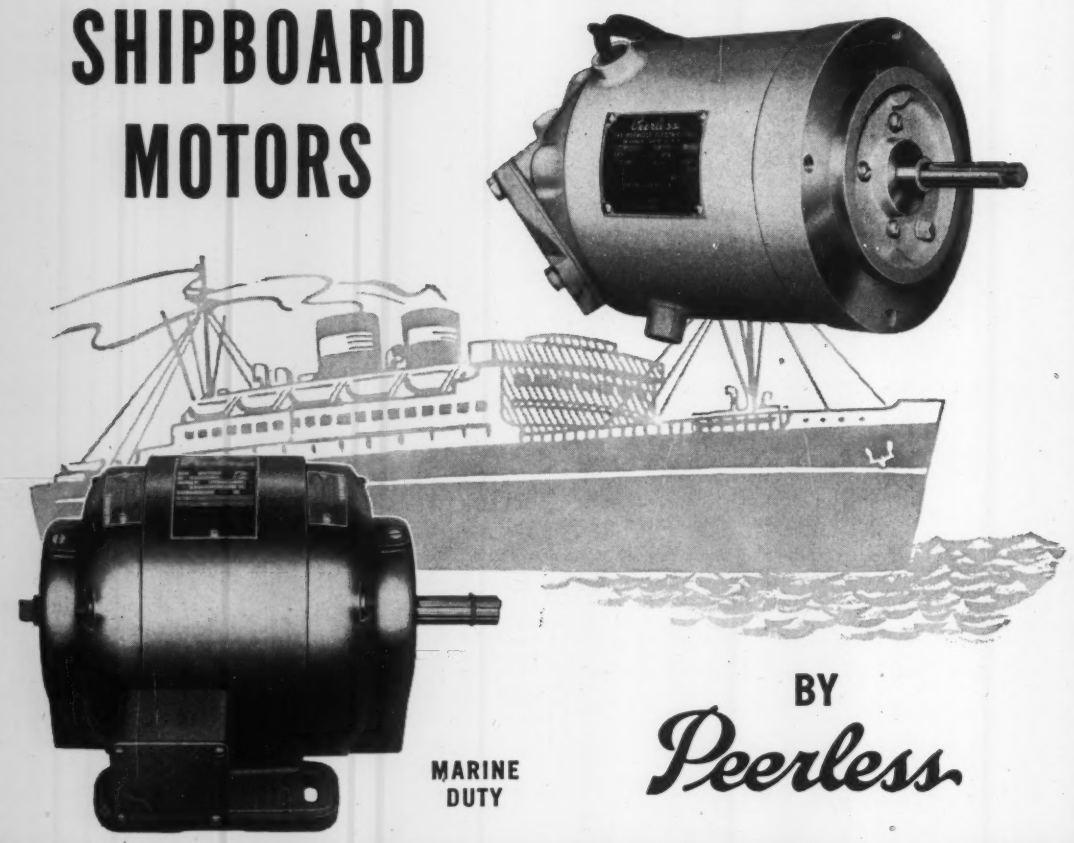
For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative. De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

SHIPBOARD MOTORS

SPRAY-TIGHT SERVICE "A"



MARINE DUTY

BY Peerless

These Peerless motors meet all critical marine codes. Spray-tight Service "A" units withstand tremendous shock, high vibration levels and great temperature changes. To remove one costs almost as much as a new motor. They must be flawless.

The Peerless Marine Duty Motor is available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from 1/2 HP to 30 HP.

Both Motors meet specifications of ABS, Mil-M-17413 (DC), Mil-M-17060-A (AC), AIEE 45 and U. S. Coast Guard. With standard or special mountings and features, they serve aboard vessels throughout the world. Give us your shipboard motor problem. We'll work with your engineers to produce the one motor that serves your needs best.

ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

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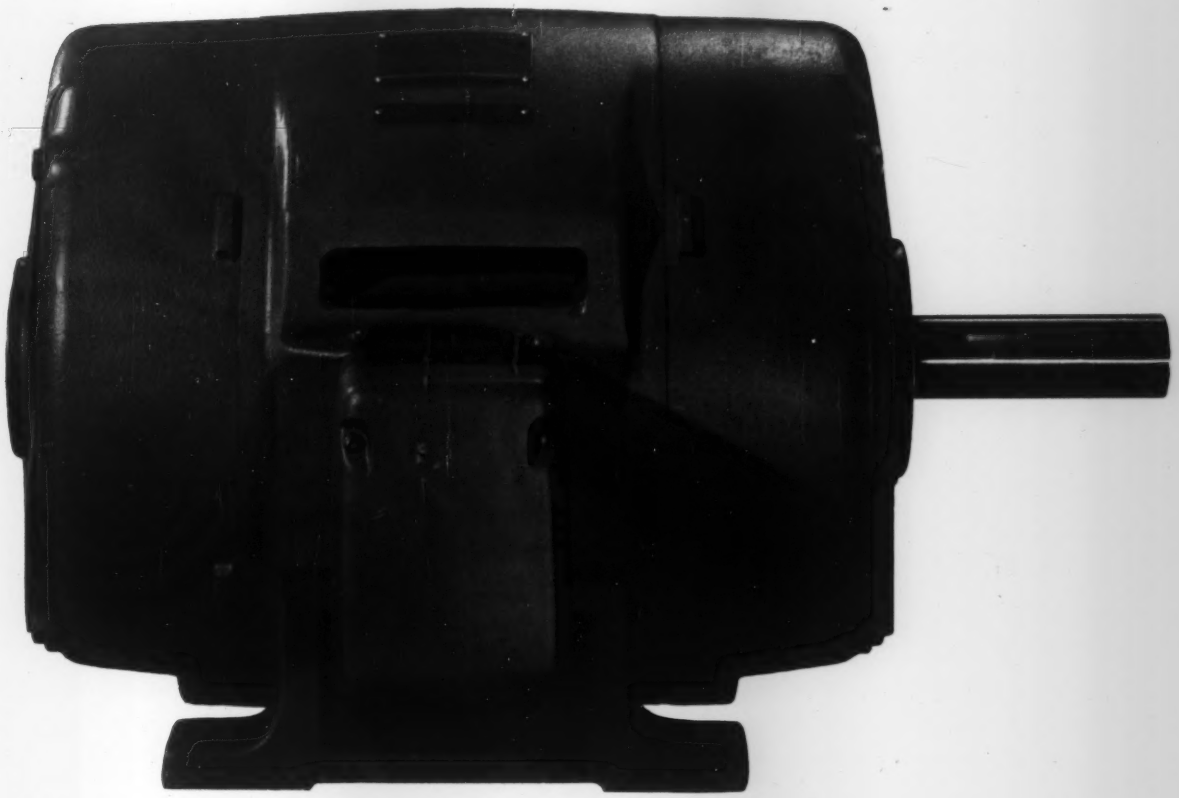
Circle 429 on page 19

Circle 630 on page 19→

NEW

FROM GENERAL ELECTRIC



TRI 55 CLAD MOTORS

REG. U.S. PAT. OFF.

NOW UP TO 125 HP

GENERAL ELECTRIC

compact . . . power-packed

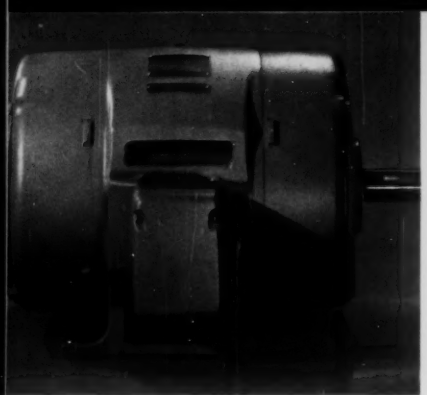
General Electric TRI 55 CLAD

REG. U.S. PAT. OFF.

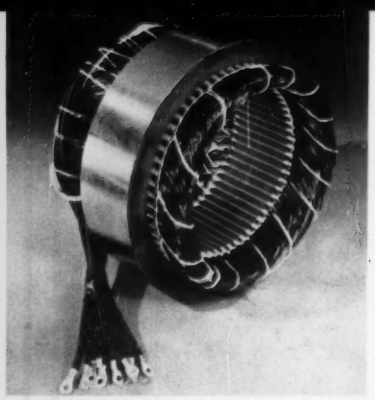
NOW UP

DRIPPROOF

DESIGNED, BUILT AND TESTED FOR

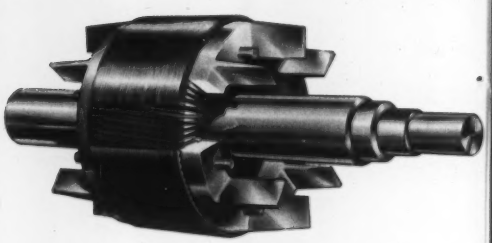


FULLY PROTECTED by cast-iron enclosures, Tri-Clad '55' motors handle many jobs where ordinary dripproof motors cannot be applied.



MYLAR* slot insulation, Formex® wire, non-wicking Geoprene® leads and Dri-Film® silicone coating increase stator life up to 50%.

*Registered Trade-mark Dupont Co.



IMPROVED ROTORS are solid cast of pure aluminum for greater strength, higher conductivity. Rotor bars are insulated from core to improve motor efficiency.

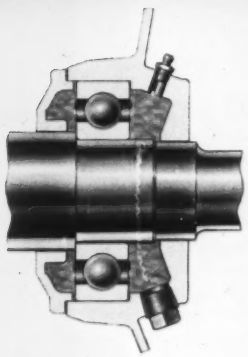
GENERAL ELECTRIC

Motors in New NEMA Ratings

TO 125 HP

TOTALLY ENCLOSED

LONGER LIFE, EASIER MAINTENANCE



BEARING SYSTEM uses over-size ball bearings, synthesized grease, long, close-running seals to extend motor life.

PERMA-NUMBERED LEADS and roomy conduit box facilitate motor hook-up. Knock-off lugs speed end shield removal for motor inspection.

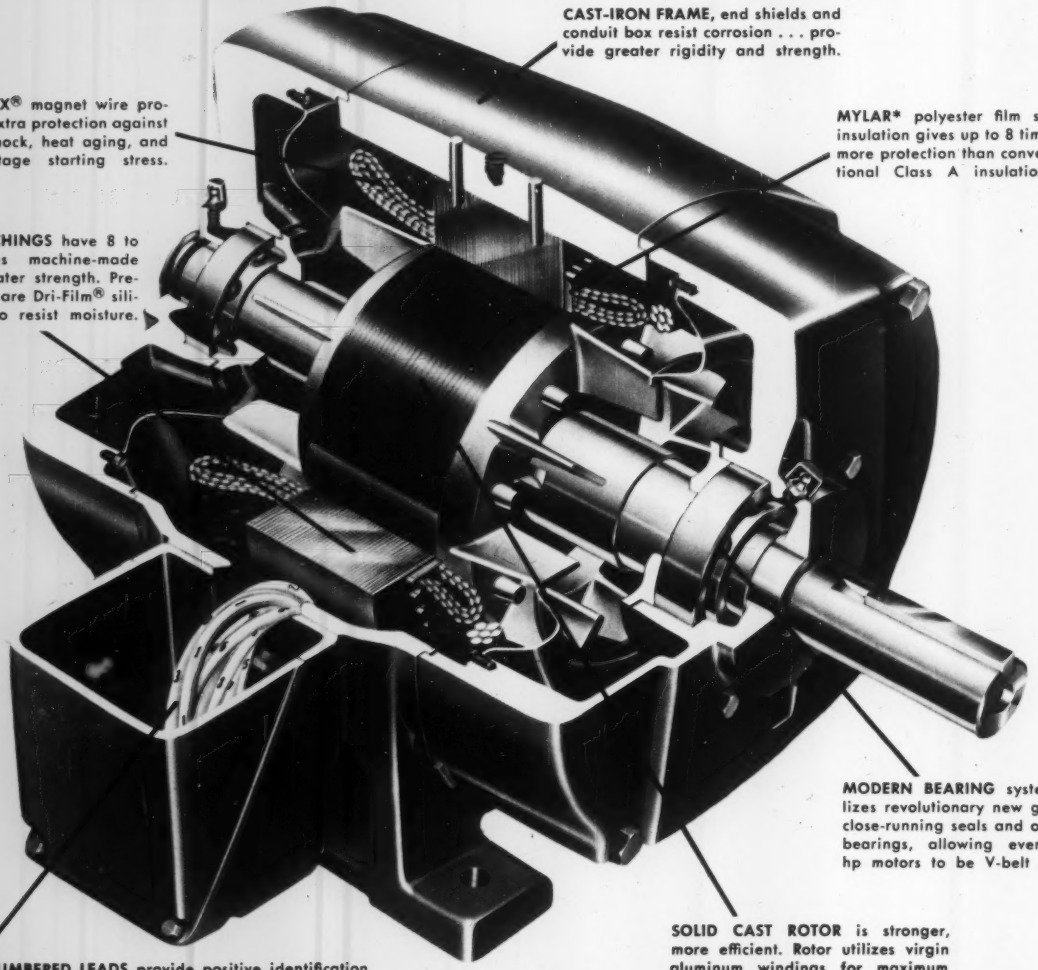
GENERAL ELECTRIC Tri-Clad '55' motors must pass a series of sound, vibration and hi-potential tests prior to shipment. Rigid tests assure uniform high-quality, and long-life performance.

TRI-CLAD give you top performance. Here's why . . .

compact . . . power-packed

Only G-E TRI 55 CLAD motors give you all these years-ahead benefits

REG. U.S. PAT. OFF.



CAST-IRON FRAME, end shields and conduit box resist corrosion . . . provide greater rigidity and strength.

FORMEX® magnet wire provides extra protection against heat shock, heat aging, and full-voltage starting stress.

MYLAR* polyester film slot insulation gives up to 8 times more protection than conventional Class A insulations.

STATOR PUNCHINGS have 8 to 16 continuous machine-made welds for greater strength. Pre-wound stators are Dri-Film® silicone-treated to resist moisture.

MODERN BEARING system utilizes revolutionary new greases, close-running seals and oversize bearings, allowing even 125-hp motors to be V-belt driven.

PERMA-NUMBERED LEADS provide positive identification even when taped, or if terminals have been clipped.

SOLID CAST ROTOR is stronger, more efficient. Rotor utilizes virgin aluminum windings for maximum conductivity, better performance.

*Registered Trade-mark Dupont Co.

FOR COMPLETE INFORMATION

Section 891-3
GENERAL ELECTRIC COMPANY
Schenectady 5, New York

Please send me the following publications:

☐ **FREE BULLETIN** (GEA-6602) describing the many advanced features of new Tri-Clad '55' motors up to 125-hp.

☐ **FREE SLIDE RULE** (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY & STATE _____

FOR COMPLETE DETAILS on the new line of Tri-Clad '55' motors up to 125 hp, contact your local G-E motor distributor or the motor specialist at your nearby General Electric Apparatus Sales Office. They will give you expert assistance in selecting and applying the right motor for your particular application.

For free slide rule to determine weight and space-saving benefits of the new motor, and for informative General Electric Tri-Clad '55' motor bulletin, please send attached coupon.

Progress Is Our Most Important Product

GENERAL ELECTRIC

See what adhesives are doing today!

A MODERN FASTENER SPEEDS THIS ASSEMBLY LINE. IT NEEDS NO HOLES, BONDS PARTS INSTANTLY. IT'S 3M ADHESIVE EC-1357.

Simplifying the assembly line

A 3M adhesive is helping to create 50 shelves per hour right before your eyes. By bonding parts instantly, EC-1357 simplifies this assembly line to just four fast operations.

One worker puts metal frames and fiberboard sheets on a conveyor moving 9 feet per minute. The second sprays EC-1357 on both as they pass by. The third positions the boards on the frames. They pass under a pressure roller and the bond is complete. There are no extra fastening steps.

Instantly EC-1357 bonds board to frame so strongly that the fiberboard will delaminate if you try to remove it. A fourth man installs molding. The shelves are ready to ship immediately.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

Learn how 3M research can speed your production, cut your costs. Consult your 3M Field Engineer. For a free booklet and more information write: 3M, Dept. 107, 417 Piquette, Detroit 2, Michigan.

PRODUCT OF 3M RESEARCH

3M ADHESIVES

ADHESIVES AND COATINGS DIVISION, **MINNESOTA MINING AND MANUFACTURING COMPANY**

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N. Y. 16, N. Y. • CANADA: P. O. BOX 757, LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Circle 430 on page 19

FENWAL'S THERMOSTATS NOW CIGARETTE SIZE

Some Units Smaller Still
Take Little More Room Than Sugar Lump

ASHLAND, MASS. — If you want to control temperatures in tight spots, you should see Fenwal. Fenwal has cut the size of thermostats way down.

You can fit one of their Midget THERMOSWITCH units anywhere a cigarette will fit. And, if you're working with even less space, one of their Miniature THERMOSWITCH units is what you're looking for. The Miniatures are little bigger than a lump of sugar, and some are even smaller.

The Midgets and Miniatures use the same unique principle used in Fenwal's bigger THERMOSWITCH controls. They use it with the same high degree of success.

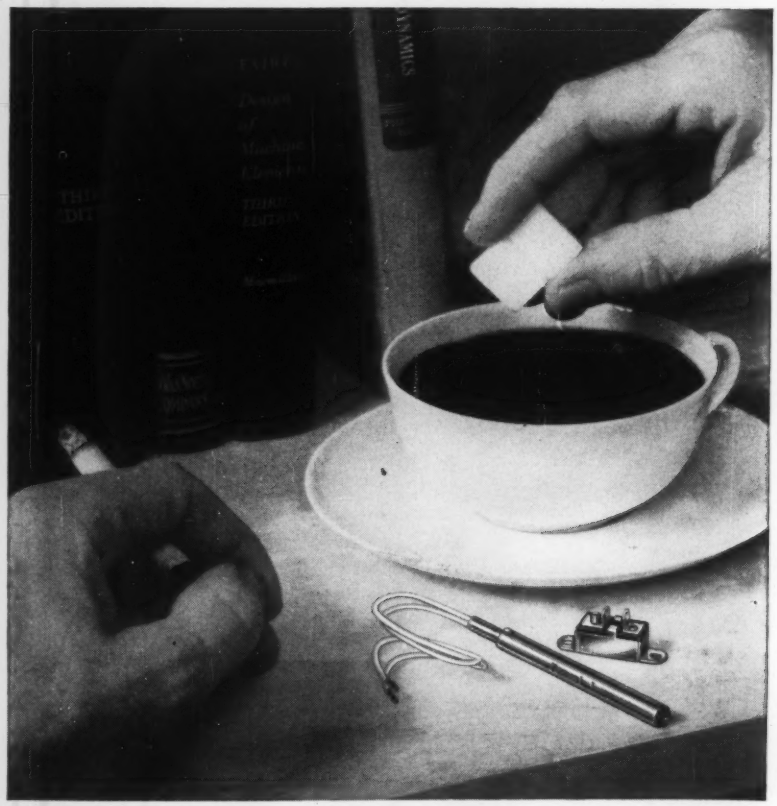
The principle of all Differential Expansion THERMOSWITCH units, large or small, is this: a single metal shell expands or contracts with temperature changes, making or breaking totally enclosed electrical contacts.

The smallness of the Midget and Miniature units does not deprive them of any of the performance characteristics that have made larger THERMOSWITCH units famous. They have THERMOSWITCH ruggedness, THERMOSWITCH accuracy, and reasonable THERMOSWITCH prices.

Temperature range of the Midget series: −50°F to 500°F. Range of the still smaller Miniature series: −20°F to 275°F.

Midgets and Miniatures, all in stainless steel, come in a variety of mountings. Hermetic sealing is also available.

These Fenwal THERMOSWITCH units are precision-engineered to give optimum temperature control with minimum-sized devices. They remain accurate under the most severe operating conditions.



THERMOSTATS FOR TIGHT SPOTS — A Fenwal Midget THERMOSWITCH® unit and a Fenwal Miniature THERMOSWITCH unit — two good answers to the question, "How can you install an accurate, reliable thermostat where there's almost no room?" Actual sizes of these particular models — ¼" x 2 25/32" for the Midget; 1" x ½" for the Miniature.

You should have details on this advance in temperature control at your fingertips. Write for information to **Fenwal Incorporated, 198 Pleasant Street, Ashland, Massachusetts.**

Fenwal

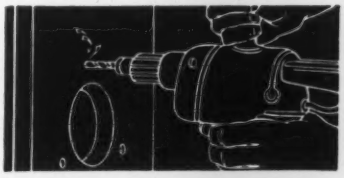
CONTROLS TEMPERATURE ...PRECISELY

Circle 431 on page 19

This Aetna Adapter Bearing is inexpensive, comes in a compact PACKAGE Unit . . . and talk about easy installation—

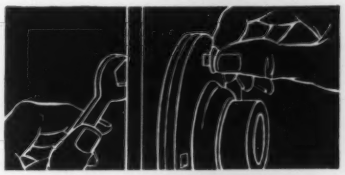
IT'S AS SIMPLE AS THIS:

A



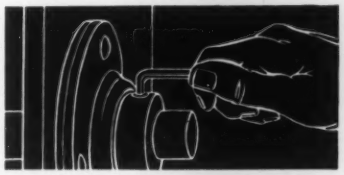
Drill (or punch) 3 bolt holes in shaft supporting member.

B



Place Adapter unit in position, insert bolts and tighten nuts.

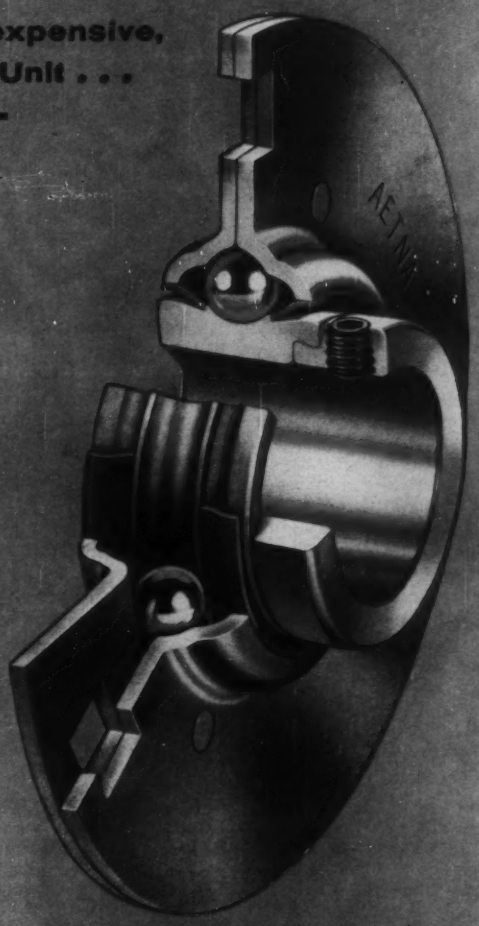
C



Install shaft, twist locking collar, tighten set screws.

And there you have it—

—all the advantages of ball bearing efficiency adapted to your current or projected equipment designs with minimum, or no engineering alterations.



Designed and built-to-be-installed-and-forgotten this permanently lubricated, sealed-for-life Adapter bearing requires no re-lubrication, no maintenance of any kind. It combines self-aligning bearing, seals, mounting flange and locking collar in a single easy-to-handle package assembly that mounts wherever shafts can be supported—including sheet metal or any semi-rigid structural members. Available in a range of standard shaft sizes. Write us or call in our local expert, your nearby Aetna distributor.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

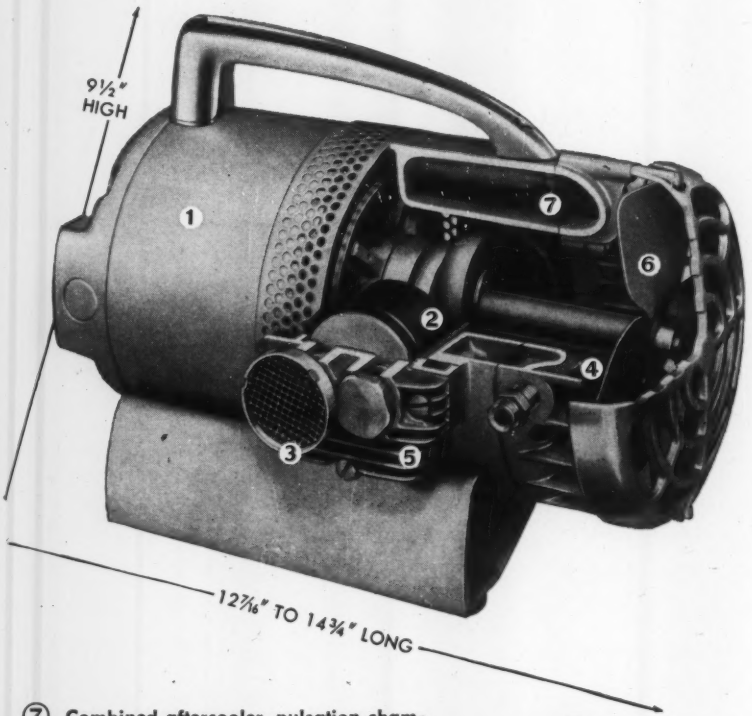
Aetna Anti-friction Consultant to Leading Original Equipment Manufacturers since 1916

Circle 432 on page 19

Oil-Free COMPRESSED AIR

from a portable or built-in unit

No more oil-spoiled work! Here is a compressor which doesn't require lubrication of any kind—eliminates an oil separator, *ends expensive lubrication maintenance!* Whether your need is for a portable or built-in source of compressed air, the compact, lightweight B&G Oil-less Compressor assures cleaner, cooler, drier air and smoother operation.



① **Specially designed motors.** Built by B&G—noted for dependability. Ball bearings are *permanently* grease packed.

② **Graphite piston rings and skirts.** Made of a special composition which does not need lubrication. Operate for years without destroying the mirror-finish of the cylinder walls. Piston ring joints are self-sealing—reduce blow-by to a minimum.

③ **Dry valve construction.** Inlet and exhaust valves are positive-sealing without presence of oil. Precision lapped—self-cleaning—no rubbing parts.

④ **Safety valve.** (Not visible.) Provides constant bleed-off at maximum pressure. Also acts as automatic moisture drain.

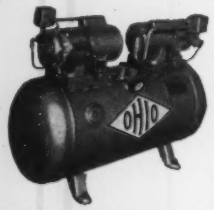
⑤ **Bi-metal cylinder head.** Deep-finned aluminum head transfers heat faster. It is cast around the cast iron cylinder, making a leak-proof shrink-fit...no gasket needed.

⑥ **Blast cooled.** The fan blasts great volumes of air over the pulsation chamber, connecting rods, bearings, cylinders and motor. Low temperature operation assures higher efficiency, longer life.

⑦ **Combined aftercooler, pulsation chamber, moisture separator.** Cooler, drier air is delivered at smooth, uniform pressure because of this integrated design.

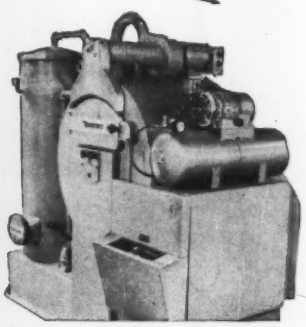
For complete information on B&G Oil-less Compressors and Vacuum Pumps, send for Catalog GO-1156

Cart mounted B&G Air Compressor



B&G "Duplex Unit" mounted on horizontal tank

New type air stapler with air supplied by B&G Compressor

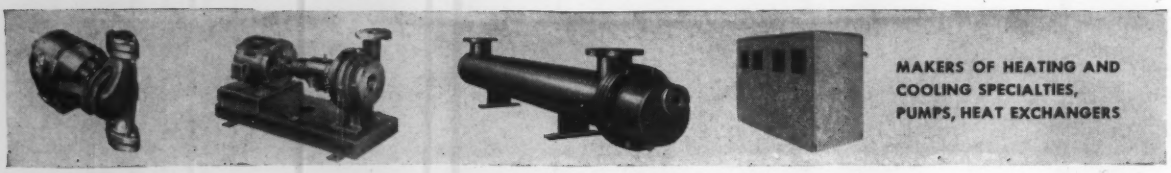


B&G Compressor built into dry cleaning machine

Oil-less AIR COMPRESSORS

BELL & GOSSETT COMPANY

Dept. EW67, Morton Grove, Illinois



How three manufacturers use Anaconda superfine-grain alloys

DURAFLEX makes swivel lamps swivel better

Berger Machine Products of Maspeth, New York, manufacturers of lighting-fixture parts, had a problem with a swivel fixture. To allow adjustment of the reflector, the two steel parts (illustrated) have to rotate 350 degrees. Steel-on-steel froze and locked. A brass ring bushing helped, but being soft allowed the steel to cut in and bind. Berger tried Duraflex, Anaconda's superfine-grain phosphor bronze, and found the answer. Its springiness, hardness and wear-resistance made a snug fit which turned easily and would hold in any position.

FORMBRITE® helps finish phone locks faster

Tele-Lock, an ingenious device for locking a dial phone, is encased in a chromium-plated brass cup. Slaymaker Lock Co., Lancaster, Pa., was using ordinary drawing brass for this cup and found finishing costs high. They turned to Formbrite, Anaconda's superfine-grain forming brass. The cups were easy to form; the slight extra spring and hardness made the fit perfect. The smooth surface of Formbrite eliminated one polishing operation and provided an ideal surface for a lasting chromium plate.

DURAFLEX makes superior contacts for Touch-Plate®

Touch-Plate Mfg. Corp., Long Beach, Calif., makes low-voltage switch systems for control of lighting in the home. It takes only a flick of the finger or elbow on the momentary contact switches to actuate a relay, or set of relays, which turns lights on or off in one room or through the house. For the contact strips in Touch-Plate wall switches they now use Duraflex, Anaconda's superfine-grain phosphor bronze, because they found it has more spring, better recovery properties. Duraflex is now used also for contacts in the relays which operate the Touch-Plate system.

FOR INFORMATION WRITE: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

5767

DURAFLEX

The new superfine-grain phosphor bronze with greater endurance limit.

FORMBRITE

The new superfine-grain drawing brass that cuts finishing costs.

ANACONDA®

PRODUCTS

MADE BY THE AMERICAN BRASS COMPANY

A copy for every designer

Table of Contents

Research and Development
General Product Description
S.A.E. Nomenclature
Metal-Encased Oil Seal Designs
One-Piece Molded Oil Seal Designs
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Installation Data
Oil Seal Application Index
Seal Sizes and Types—by Shaft Diameter
Seal Sizes and Types—by Numerical Listing
Metal-Encased Felt Seal Listing

Compiled Entirely to Serve Specifier's Needs

You'll quickly see this is not just the usual reference catalog that tells you what you can have. Instead, this new, modern edition shows and tells you how to get the oil seal you need —and how to insure effective performance.

60-page working guide

Here you will find all essential data for modern oil seal specification procedure—much of it in useful form for the first time in any catalog. Every section in the contents table offers valuable help toward better shaft sealing.

Note 2 outstanding features:

All sizes and types of Victor designs are grouped by shaft diameter—the primary consideration. A cross section of each design is immediately adjacent for quick reference.

Specific recommendations are given on design adaptability in relation to pressure, temperature, and shaft speed conditions.

Your copy sent on request

The more you use this catalog, the more you will be impressed with the fact of Victor's pre-eminence in the quality oil seal field, both in meeting your standard as well as custom requirements.

Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Limited, St. Thomas, Ont

VICTOR

Sealing Products *EXCLUSIVELY*

OIL SEALS • GASKETS • PACKINGS • MECHANICAL SEALS

Circle 435 on page 19

Skinner Solenoid Valves are easier to maintain and service because of their simplified design

The man shown above is cleaning a Skinner Solenoid Valve. He has disassembled it by hand without removing it from the line. Simplicity of design makes this simple maintenance and service feature possible. The design of Skinner valves is such that coils and other parts are interchangeable and easily, quickly replaced. They are readily available, too — reducing the stocking of spare parts to a minimum.

Skinner Solenoid Valves are made of the very finest materials available and contain only two moving parts. Their joints are heli-arc welded on special electronically controlled equipment. Their coils, manufactured to UL standards, will operate for years without burnout. Their positive spring returns eliminate sticking. And they have no packing to wear out and cause leakage.

If you are looking for solenoid valves that will give you longer trouble-free performance, look to Skinner valves. For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 427.

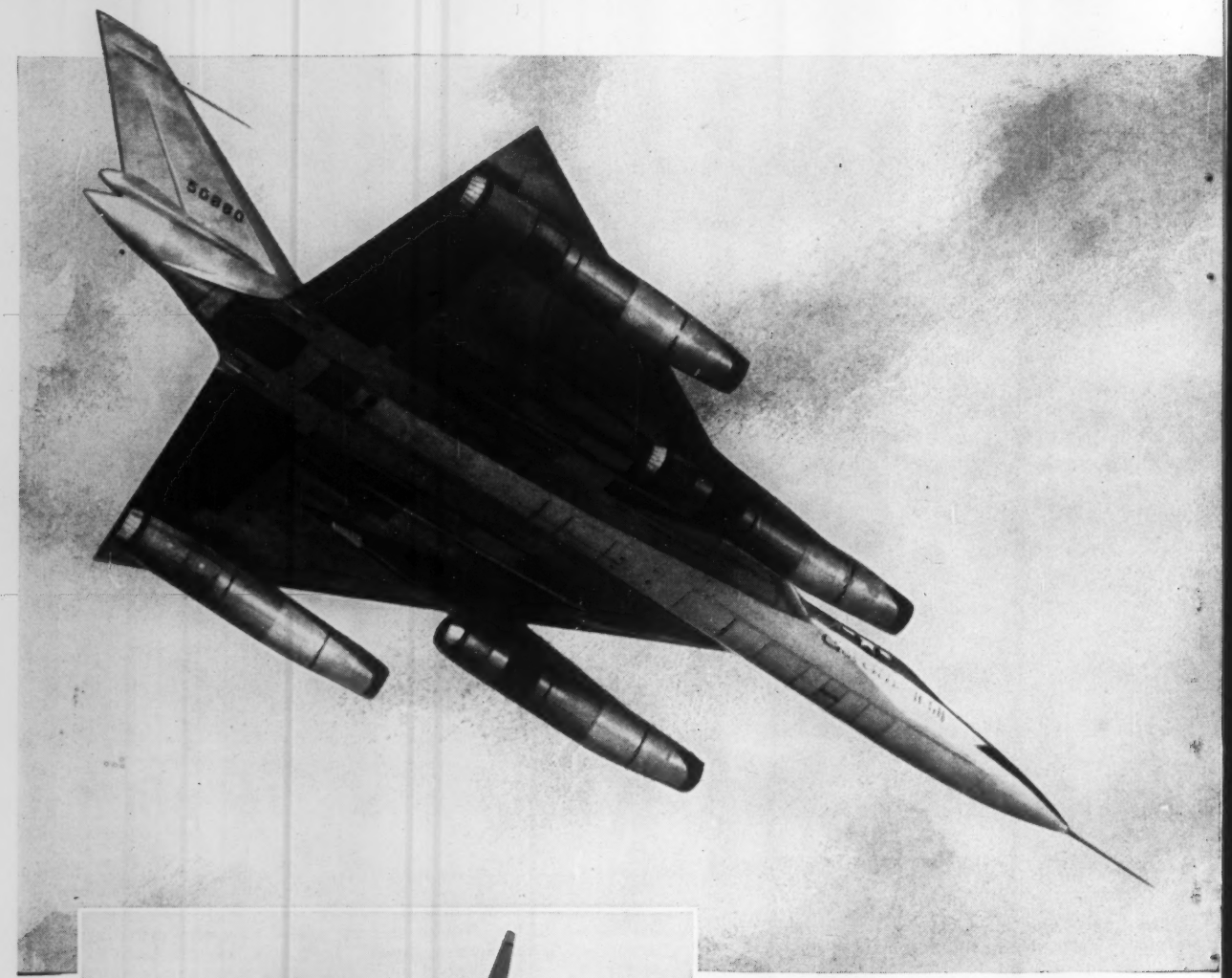
Skinner Solenoid Valves are distributed nationally

Circle 436 on page 19

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

Republic Titanium Flies with



The B-58 is built for the Air Force by Convair, A Division of General Dynamics Corporation, Fort Worth, Texas. Powered by four General Electric J-79 engines, the plane is designed to operate at altitudes above 50,000 feet. Photo at left is one of the first showing detachable pod under fuselage. This feature permits performance of a greater variety of missions.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Convair's B-58 Hustler

Republic titanium alloys used for elevated temperature applications and weight saving in America's first Supersonic Bomber

The delta-winged B-58's transformation from drawing board to production in record-breaking time is a tribute to the design-and-engineering skill of Convair Division, General Dynamics Corporation.

This dream plane incorporates the most advanced equipment and utilizes the latest engineering materials, including Republic Titanium.

Titanium alloy types produced by Republic Steel are used in the B-58 for weight saving and elevated temperature applications. These particular titanium alloys are among the strongest now being produced. They offer high strength values at elevated temperatures.

These alloy types have a minimum tensile strength of 130,000 p.s.i. and a minimum yield strength of 120,000 p.s.i. They meet the demand for high strength to resist the effects of aerodynamic heating in supersonic aircraft, such as the B-58.

The Hustler is the world's fastest bomber. What about the future? Right now, planes are being designed for speeds of Mach 3 or 4. Republic is keeping pace. At the Titanium Research Laboratory in Canton, Ohio, new titanium alloys are being developed with better physicals to provide greater operating efficiencies.

In exploring the "thermal thicket", many materials must be appraised and utilized. Republic—world's largest producer of aircraft steels—is working on new high-tensile, stainless types with higher strength and greater heat-resistance.

Republic metallurgists and engineers pioneered the development of high strength-to-weight metals. They offer you years of experience gained through helping hundreds of manufacturers design and redesign their products to get more strength with less weight at less cost. Contact your local Republic sales office for more information. Or send us the coupon.

STEEL

and Steel Products

MORE REPUBLIC PRODUCTS WITH ADVANTAGES FOR DESIGNERS AND EQUIPMENT BUILDERS

STRUCTURAL APPLICATION PROBLEMS requiring low weight plus high strength are best solved using tubular construction. A good example is this rocket sled designed to withstand extreme forces of abrupt deceleration. Republic ELECTRUNITE® Steel Mechanical Tubing is ideal for such an application. Uniform in wall thickness, concentricity, strength and ductility, it permits reduction in bulk without sacrifice of safety. Send coupon for more facts.

ALLOY STEEL IN THE NORTH AMERICAN F-100 landing-gear struts provides strength, toughness, maximum resistance to fatigue. Exacting requirements for inner and outer cylinders resulted in the development of a new grade of steel by Bendix Aviation Corporation and Republic metallurgists working with North American engineers. This new steel, designated AMS 6427, was found ideal for application in the strength range of 220,000-240,000 p.s.i. It maintains its great strength at wide temperature extremes. Write for more information on alloy steels.

REPUBLIC STEEL CORPORATION
DEPT. C-4050A
3130 EAST 45th STREET • CLEVELAND 27, OHIO

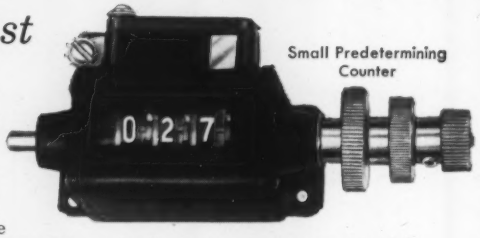
Have a metallurgist call. ☐ Titanium ☐ Alloy ☐ Stainless
Send more information on:
☐ Titanium ☐ Alloy Steels
☐ ELECTRUNITE Mechanical Tubing

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 437 on page 19

Here's why it pays to CALL FOR HELP

. . . first thing instead of last



Small Predetermining Counter

If you want to do anything "by the numbers," first thing to do is call the No. 1 man . . . your Veeder-Root District Engineer. Because he's an *original thinker* like yourself when it comes to designing or building *Count*rol into any type of product or process.

He knows his book on the most complete line of standard electrical, mechanical and manual counters made anywhere in the world. And from this line he can very likely adapt or modify a standard counter to your special needs. This saves cost and time in engineering, purchasing, assembly.

And you get a lot of new user-benefits to merchandise . . . direct readings, rather than dials and scales . . . remote indication from plant to office if needed . . . production figures that serve as a fair base for wage and incentive payments, production and stock *Count*rol, tax computation . . . and as proof of your own performance guarantee. So call the V-R man in, *when you begin* . . . look him up in your local phone book, or write direct to:

VEEDER-ROOT INC., Hartford 2, Connecticut

Added Evidence that

Everyone Can Count on VEEDER-ROOT

Hartford, Conn. • Greenville, S. C. • Chicago • New York • Los Angeles • San Francisco • Montreal • *Offices and Agents in Principal Cities*

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern appliance design

Make it more attractive—longer-lasting—easier to keep clean. And keep it simple to make. More and more designers "build in" such powerful selling points with stainless steel.

Stainless keeps pace with modern trends. Now there are more than 30 different types and a variety of textures, surface tones and colors. The hard-selling values of superior corrosion resistance, durability and toughness, long associated with stainless give you assurance of consumer acceptance at the point-of-sale.

For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steel. Ask for the booklet "Stainless Steel in Product Design." Write ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 E. 42nd Street, New York 17, N. Y. *In Canada:* Electro Metallurgical Company, Division of Union Carbide Canada Limited, Toronto.

METALS DO MORE ALL THE TIME ... THANKS TO ALLOYS

Stainless steel styling adds the attractive, durable, "easy-to-clean" appeal which is helping to put across this new idea in cooking units.

Electromet
FERRO-ALLOYS AND METALS

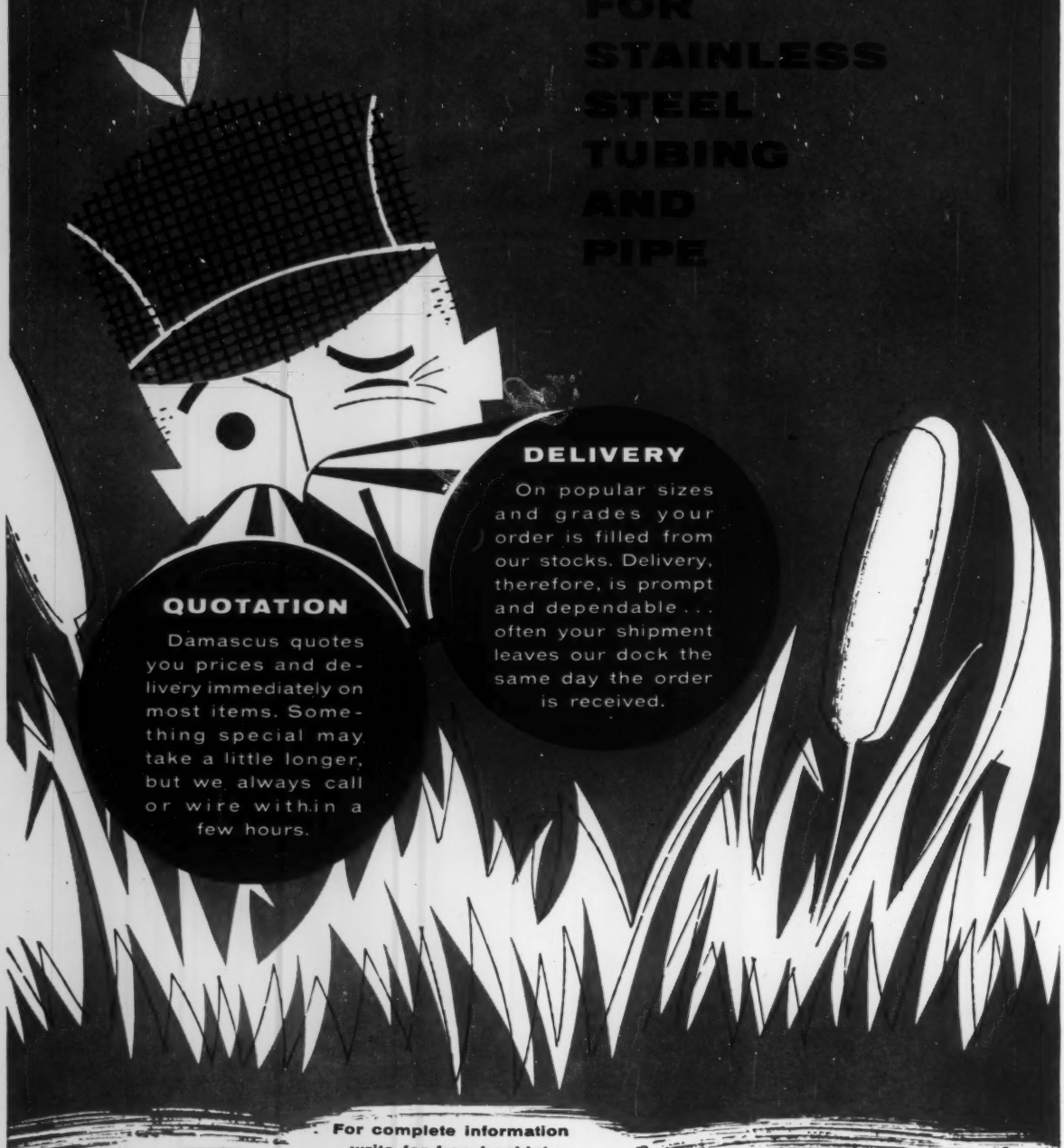
UNION CARBIDE

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 439 on page 19

DOUBLE-BARREL SERVICE

FOR STAINLESS STEEL TUBING AND PIPE



QUOTATION

Damascus quotes you prices and delivery immediately on most items. Something special may take a little longer, but we always call or wire within a few hours.

DELIVERY

On popular sizes and grades your order is filled from our stocks. Delivery, therefore, is prompt and dependable . . . often your shipment leaves our dock the same day the order is received.

For complete information write for free booklet.

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

FORMED STEEL TUBE INSTITUTE

Circle 440 on page 19

THE PACKAGED SEAL
of a hundred uses

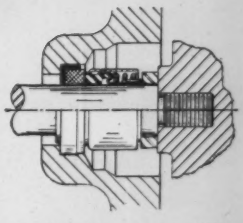
This Garlock MECHANIPAK* Seal BB-21A has proved itself on hundreds of jobs, sealing against water, oils, alcohol, mild acids, and solvents. It's ideal for shafts on centrifugal pumps, automatic washers, speed reducers, commercial dishwashers . . . wherever pressures do not exceed 150 psi.

Withstands temperatures to 212° F. with standard bellows or up to 400° F. with silicone rubber bellows . . . shaft speeds to 2000 fpm and higher depending on operating conditions. Sizes for 3/8" to 3" dia. shafts. Mechanical drive arrangement is engineered to eliminate slippage and simplify installation.

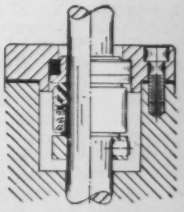
The BB-21A is another important part of "the Garlock 2,000"... two thousand different styles of packings, gaskets, and seals to meet all your needs. The only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today or write for Catalog AD-150.

*Registered Trademark

TYPICAL INSTALLATIONS



Centrifugal pump installation where stationary seat fits in housing and impeller provides stop for seal. A cup type vibration ring holds stationary seat. (Vibration ring design optional.)



Vertical shaft installation where lock-nut positions seal on shaft and stationary seat is in gland. A square vibration ring is used to hold stationary seat. (Vibration ring design optional.)

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For prompt service, *contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

Circle 441 on page 19

Fastener Facts

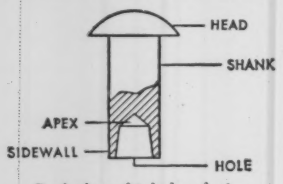
by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN PRODUCTION & PURCHASING DATA

FASTENING WITH SEMI-TUBULAR RIVETS

WHY RIVETS?

You specify rivets when you want strong, permanent fastening at low cost. However, secure fastening is not their only function. You can also use them as fulcrums, pivots, cam followers, electrical contacts, studs, stops and in many other applications.



Typical semi-tubular rivet

WHY SEMI-TUBULAR RIVETS?

You specify semi-tubular rivets when you want to combine the high shear and compression strength of solid rivets with low-cost, high-speed fastening. The required strength is inherent in the design of Thomson Semi-Tubular Rivets.

Shallow holes in solid shanks distinguish semi-tubular rivets from other types. The hole is seldom deeper than shank diameter. Its depth is determined by clinch requirements of specific applications. A general rule is to select a rivet with length equal to the thickness of the materials *plus* 55% of the diameter of the shank. A Thomson engineer can quickly specify the correct rivet length and hole depth for any particular semi-tubular riveting application.

Semi-tubular rivet applications call for pre-drilled or punched holes in the materials to be fastened: metals, plastics, wood, ceramics and other hard materials. The size of the prepared holes is an important design consideration. When holes are too small, rivets choke. When too large, rivets buckle. To avoid either error, make sure that each hole is about 7% larger than the maximum shank diameter of the rivet. In most cases, the setting process causes shank expansion sufficient to fill the hole. Again, Thomson engineering is at your service to help you match rivet and hole sizes.

High shear strength of semi-tubular rivets is further assured by Thomson production methods. All Thomson Semi-Tubular Rivets are made from specially prepared wire by the cold heading or upsetting process. This results in fasteners with the uniform structure and *inherent strength of forgings* . . . properties not achieved by screw-machine rivet production.

Standard materials used to produce Thomson Semi-Tubular Rivets include aluminum, brass, copper, nickel-silver, low-carbon steel and stainless steel. For special electrical and electronic contacts, coin silver, fine silver, palladium and other precious metals may be specified.

Finishing to specifications is another service of interest to design engineers. Rivets can be plated with brass, cadmium, copper, nickel, tin, zinc, etc. Morever, they can be oxidized or finished in japanned colors to match the original equipment or product.

Low fastening costs result from the application of Thomson Semi-Tubular Rivets with automatic rivet-setting machines. The low cost of rivets, as compared with most other fasteners, combined with high machine speeds invariably leads to production line economies. Machines are low in initial cost and require little maintenance. Furthermore, they can be operated by unskilled labor.

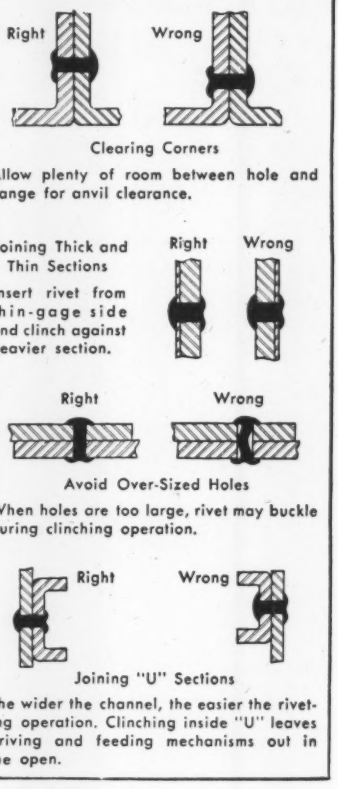
FLOOR-TYPE FOOT-OPERATED — FLOOR-TYPE MOTOR-OPERATED

HIGH PRODUCTION RIVET-SETTING MACHINES

Thomson has developed more than 200 styles of modern, high speed machines which can be adapted to innumerable fastening jobs. These machines are divided into three basic models: floor type with foot-pedal operation, floor type with motor operation, and bench type with motor operation. All permit automatic hopper feed for maximum speed, and some motor driven floor models are equipped for multiple rivet-setting.

Special work-handling devices accelerate riveting operations. Radial or turret feeds are common accessories for machines geared to high-production fastening of parts, as are all types of special loading fixtures. Thomson selects the proper machine to do your job most efficiently and custom-tools it to fit your fastening requirements.

DESIGN PRACTICES


Right
Wrong
Clearing Corners
Allow plenty of room between hole and flange for anvil clearance.
Joining Thick and Thin Sections
Right
Wrong
Insert rivet from thin-gage side and clinch against heavier section.
Right
Wrong
Avoid Over-Sized Holes
When holes are too large, rivet may buckle during clinching operation.
Right
Wrong
Joining "U" Sections
The wider the channel, the easier the riveting operation. Clinching inside "U" leaves driving and feeding mechanisms out in the open.

DESIGN & ENGINEERING SERVICE

We will gladly evaluate your fastening problems without cost. Contact us while designs can still be modified for lowest cost fastening method. Simply send sketches, prints, or preferably samples of actual work.

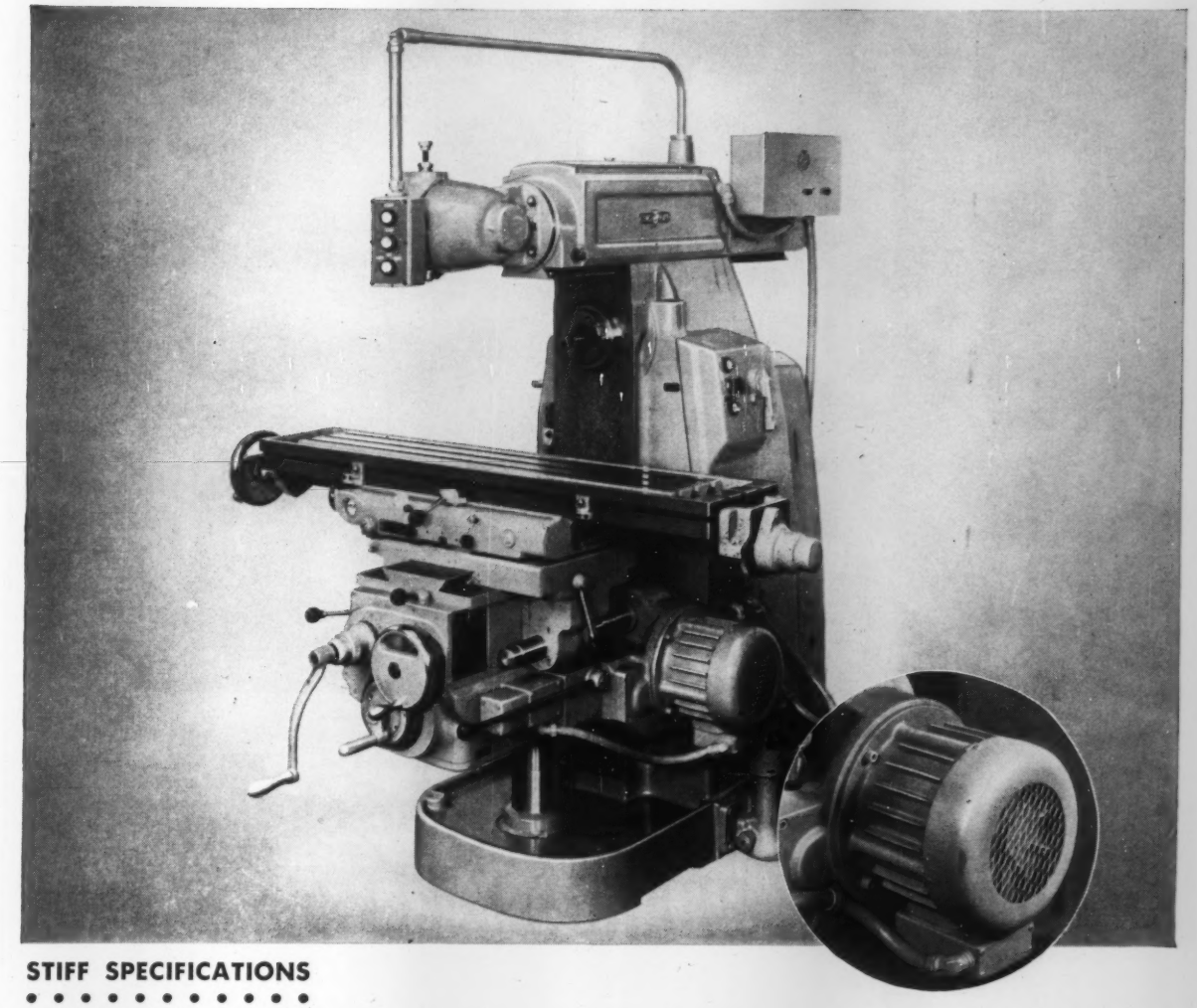
FREE "FASTENER FACT FILE"

(Due off press in a few weeks)

Be one of the first to profit from our new manual on all phases of riveting. It covers rivet types, applications, materials, finishes, and other factors that determine selection of the right design, rivet and machine for cutting fastening costs. Reserve your copy today. Write Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Massachusetts.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

Circle 442 on page 19



STIFF SPECIFICATIONS

Yet a DIEHL motor met all requirements

The requirements of one of the largest milling machine manufacturers called for a close-coupled, special duty motor to raise and lower the knee and develop sufficient torque for heavy table loads in rapid traverse without stalling. Cool operation was imperative to avoid distortion of the machine table due to heat transfer. The motor was to be mounted directly on the gear case, therefore complete protection against oil leakage into the motor was essential. Motor size, compactness and appearance were important factors. DIEHL developed the special totally enclosed motor illustrated, which met all desired requirements. Cool operation was assured by the fan-cooled design of the motor, effectively preventing heat transfer. The flat-type construction saved considerable space and overhang, conforming well with machine contours. Positive and dependable machine operation was the end result.

This is another example of DIEHL accomplishment based on almost three-quarters of a century of experience in the design and manufacture of motors for industry. Utilize this experience in the solution of your motor problems. We'll work closely with you to provide the right motor — at the right time — at the right price.

DIEHL MANUFACTURING COMPANY
Electrical Division of
THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

Diehl

☐ Please send me Consolidated Motor Catalog and Price List No. MD-7—3540

☐ Please have a DIEHL representative call

NAME _____

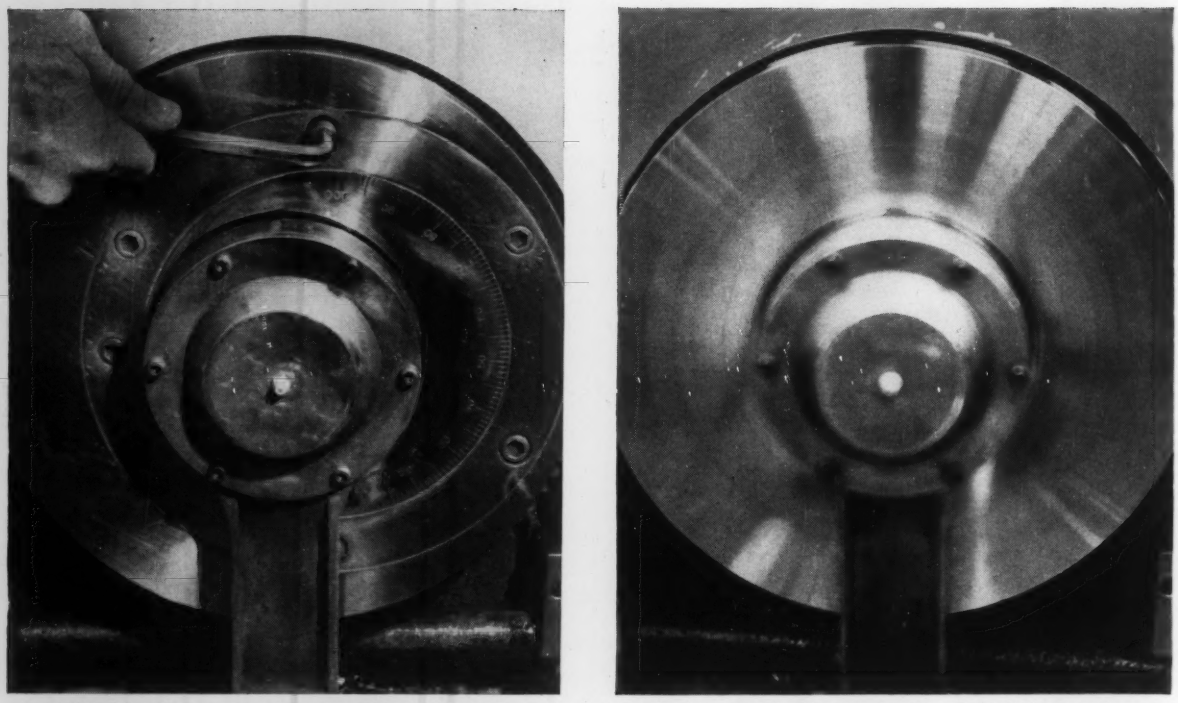
COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

Baltimore • Chamblee, Ga. • Charlotte • Chicago • Cincinnati • Milwaukee • Needham, Mass. • New York • Philadelphia • Syracuse

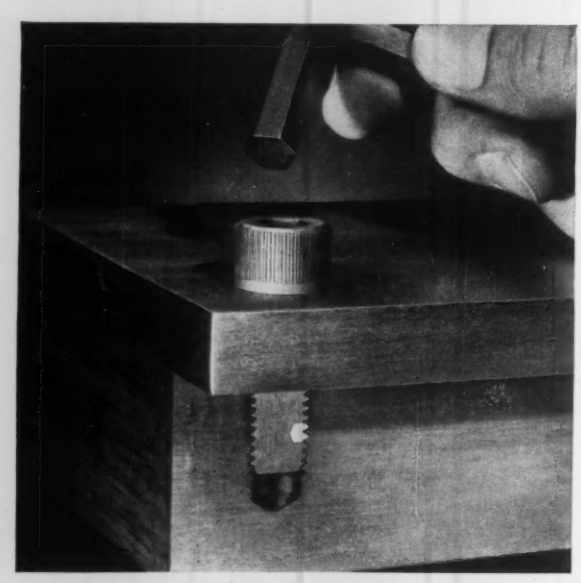
Circle 443 on page 19



Self-locking UNBRAKO socket screws keep critical adjustments secure in the eccentric drive mechanism of this fatigue testing machine. Drive system delivers varying loads up to 15,000 pounds force to equipment under test at 1050 cycles per minute.

Vibration won't loosen Self-locking UNBRAKO socket cap screws

Screws with Nylok* device permit adjustments, keep precise settings during long test runs



HOW IT LOCKS. The tough, resilient Nylok locking pellet keys itself into the mating threads. It forces threads together, and locks the screw securely—whether or not the screw is seated.

UNBRAKO socket screws with the Nylok self-locking device stay tight under constant vibration.

Take the eccentric drive system in the fatigue testing machine illustrated above, for example. This machine must frequently run for periods up to 2 weeks or longer, day and night, to complete a single test. Loosening of the screws which are used to adjust the tension-setting mechanism could not only cause damage to the machine, but also make the test data worthless. Self-locking UNBRAKO socket head cap screws eliminate such problems.

An UNBRAKO socket screw with the Nylok self-locking device is a single unit. Just screw it into any tapped hole. Seated or not, it locks positively wherever wrenching stops. Constant vibration or pounding, or endless running of a machine, won't affect these self-locking UNBRAKOS. The screws will not work loose!

Write today for your copy of Form 2193, which gives complete catalog and technical data on the entire line of UNBRAKO socket screws with the Nylok self-locking device. Or see your authorized industrial distributor. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

*T.M. Reg. U.S. Pat. Off. The Nylok Corporation

Circle 444 on page 19

NEW GOLDEN BONDERITE

How its golden color can mean better products, greater profits for aluminum fabricators

The golden coating achieved on aluminum by new Golden Bonderite is the key to a whole new concept in control, economy and efficiency.

No longer need you worry along with variations in coating weights and solution analyses that go up and down from hour to hour or day to day. The color of the metal as it emerges from the Bonderite machine is a visual check on solution effectiveness and coating quality. It looks the same—and it is the same—24 hours a day, seven days a week.

Parker "Reactifier" and How It Works

In ordinary surface treatment solutions of this kind, a build-up of impurities occurs as work is processed. These impurities affect the efficiency of the treatment in inverse ratio until finally the solution is beyond redeeming. The tank has to be dumped and a fresh bath made up.

This costly, wasteful procedure is ended when you use Golden Bonderite in conjunction with the sensational Parker "Reactifier" column, an exclusive apparatus that polices the solution constantly, removing the harmful elements and allowing you to use the solution indefinitely, without ever having to discard it.

Better Products, Better Profit

You use a surface treatment for your aluminum production to improve paint adhesion and corrosion resistance, to reduce rejects in the finishing department and to assure customer satisfaction. Uneven efficiency in surface treatment usually means loss of paint adhesion, production rejects and the danger of costly field service and replacements.

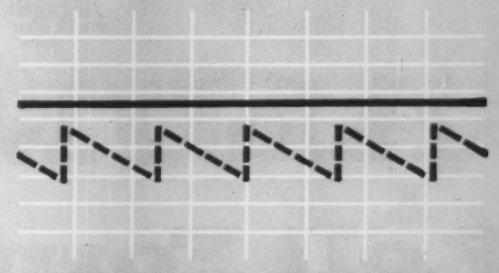
Golden Bonderite's uniform efficiency, so easily checked by color, will save you money.

1 It provides a uniform, effective paint base.

2 It allows you to schedule and maintain high production levels.

3 It permits operation at uniform low chemical concentrations.

4 It eliminates the need for dumping and rebuilding treatment solution.



Straight-as-a-string solution analysis

The saw-tooth line above is entirely too familiar to operators of conventional aluminum treatments. Efficiency sags as metal is treated, recovers as chemical is added, quickly sags again in use. Quality is uneven and uncertain.

New Golden Bonderite and the amazing new "Reactifier", developed by Parker, bring "straight-as-a-string" efficiency. No variation in quality even if you operate 24 hours a day, seven days a week. Solution analysis remains constant, free of impurities that reduce efficiency and quality.

Simple To Use

New Golden Bonderite may be applied by spray or immersion. Treatment time can be varied to suit production speeds and equipment. Golden Bonderite comes to you in concentrated liquid form, easy to handle and use.

Let us show you actual samples and test data on Golden Bonderite for aluminum. Call or write today!

NOTE: *A companion product to Golden Bonderite produces an appealing scratch-resistant green coating on aluminum. It's a lovely color without further finishing. A natural for architectural products.*

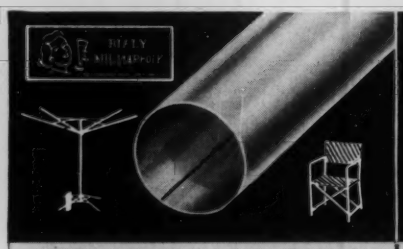
Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

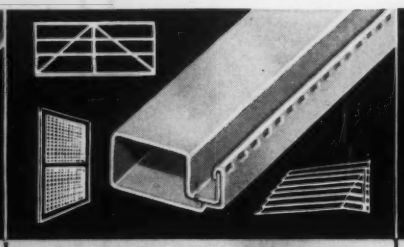
BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

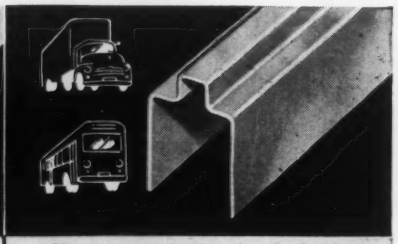
Circle 445 on page 19



High strength and superior finish of aluminum roll formed tubing pays off in sign frames of all sizes, aluminum furniture, clothes dryers and other products.



Parts for window screens, farm gates, car ports, awnings and other building products are economically produced with aluminum roll formed shapes.



Many complex truck and trailer framing members, bus strips and other parts are easily fabricated with aluminum roll formed shapes.

Specify ALUMINUM Roll Formed Shapes from REYNOLDS

available now in embossed patterns, paint finishes and plain or color anodized finishes

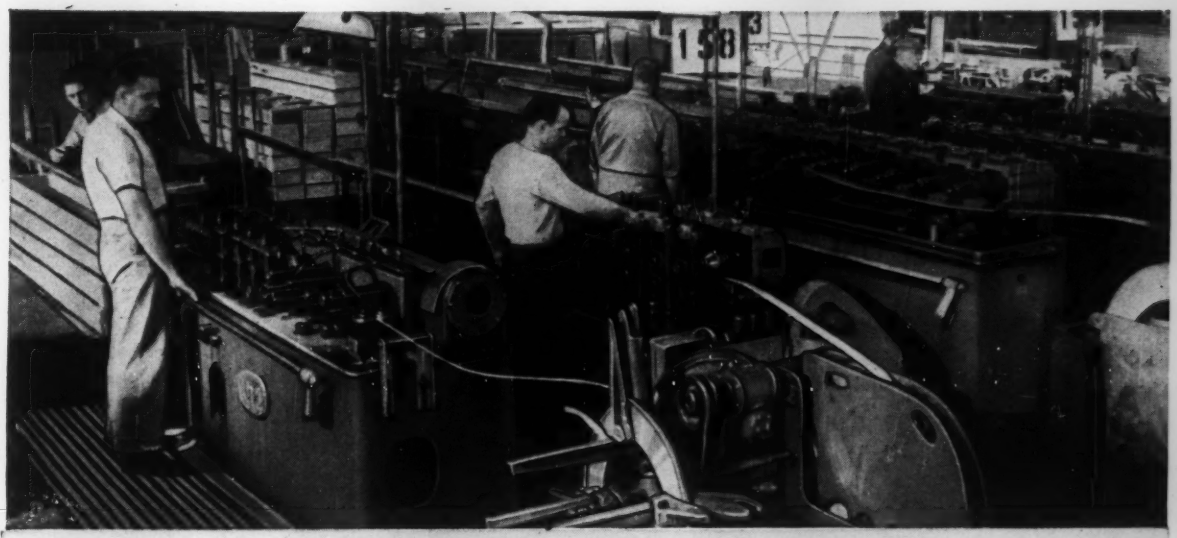
Rolling from coil stock *permits savings* that are impossible when working from flat sheet. Therefore, if you are fabricating a complex shape from flat sheet, or if you require a shape in long lengths, it will pay to switch to aluminum roll formed shapes from Reynolds.

Reynolds roll forming can produce a wide range of easily fabricated shapes that *aid in design flexibility*. Closer tolerances on Reynolds roll formed shapes mean *dimensional accuracy;* better as-fabricated finishes often mean a *more attractive* product without additional finishing operations.

However, if an unusually high quality finish is important to the sales appeal of your aluminum product, Reynolds is your best source for *clear anodized, color anodized, painted* or *chemically brightened* finishes or *embossed patterns* on roll formed shapes. Reynolds new, expanded finishing facilities complement Reynolds sizable investment in roll forming machines and tooling.

For details contact your nearest Reynolds Office listed or write *Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Kentucky.*

REYNOLDS ALUMINUM FABRICATING SERVICE



The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

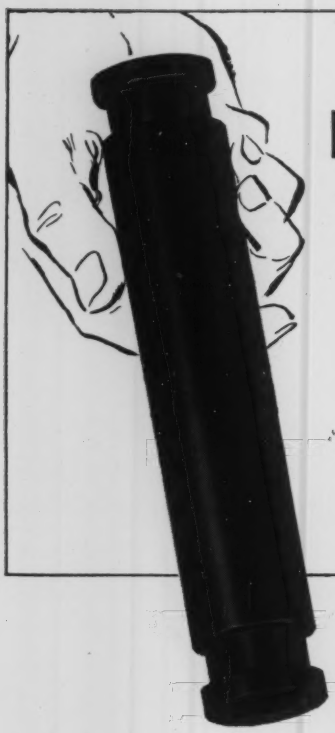
© REYNOLDS METALS COMPANY

Write for your free copy of 8-page brochure, "Aluminum Roll Formed Shapes by Reynolds".

See "CIRCUS BOY", Reynolds dramatic series, Sundays, NBC-TV

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING

FORMING • ROLL SHAPING • TUBE BENDING • WELDING • BRAZING • FINISHING



Large Part...Small Part ...in Natural or Synthetic Rubber...

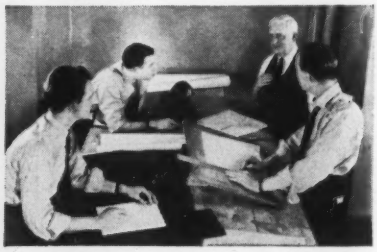
PHOENIX 4-STEP SERVICE

ASSURES A BETTER END PRODUCT

Phoenix 4-Step Service can be of invaluable assistance in helping you utilize rubber to develop a better end product. Compounding and fabricating rubber has been a Phoenix specialty for 25 years. This concentration enables Phoenix to develop natural and synthetic rubber compounds to solve a variety of product design problems involving such factors as high and low temperature, abrasion, weather, load, torque, corrosive fluids and bonding to other materials. You can confidently put *your* rubber problem to Phoenix for an imaginative and thoroughly satisfactory solution!

Leading Manufacturers of Custom Molded Mechanical Rubber

STEP 1—ANALYSIS Phoenix studies the part to determine which will be the most suitable rubber compound.



STEP 2—DESIGN Phoenix assists in designing the part to perform the function intended at an acceptable cost.

STEP 3—COMPOUNDING Then Phoenix compounds and tests the most suitable natural or synthetic rubber.

STEP 4—MANUFACTURE Modern equipment and exacting production control assure fast, accurate molding.

PHOENIX

RUBBER PRODUCTS DIVISION
PHOENIX MANUFACTURING COMPANY
JOLIET, ILL. • **FOUNDED 1882**

Integrated Manufacturing Facilities: RUBBER PRODUCTS DIVISION, FLANGE AND FORGING DIVISION, STEEL MILL DIVISION, STEEL BUILDING PRODUCTS DIVISION, HORSESHOE PRODUCTS DIVISION

Circle 447 on page 19

GET SQUARE D SAFETY SWITCHES AND BENEFIT FROM THE NEW NEMA STANDARDS

NEMA standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser, as well as to assist the purchaser in selecting and obtaining the proper product for his particular need.

Square D's quick change to the new standards gives you the performance and safety which NEMA standards assure.

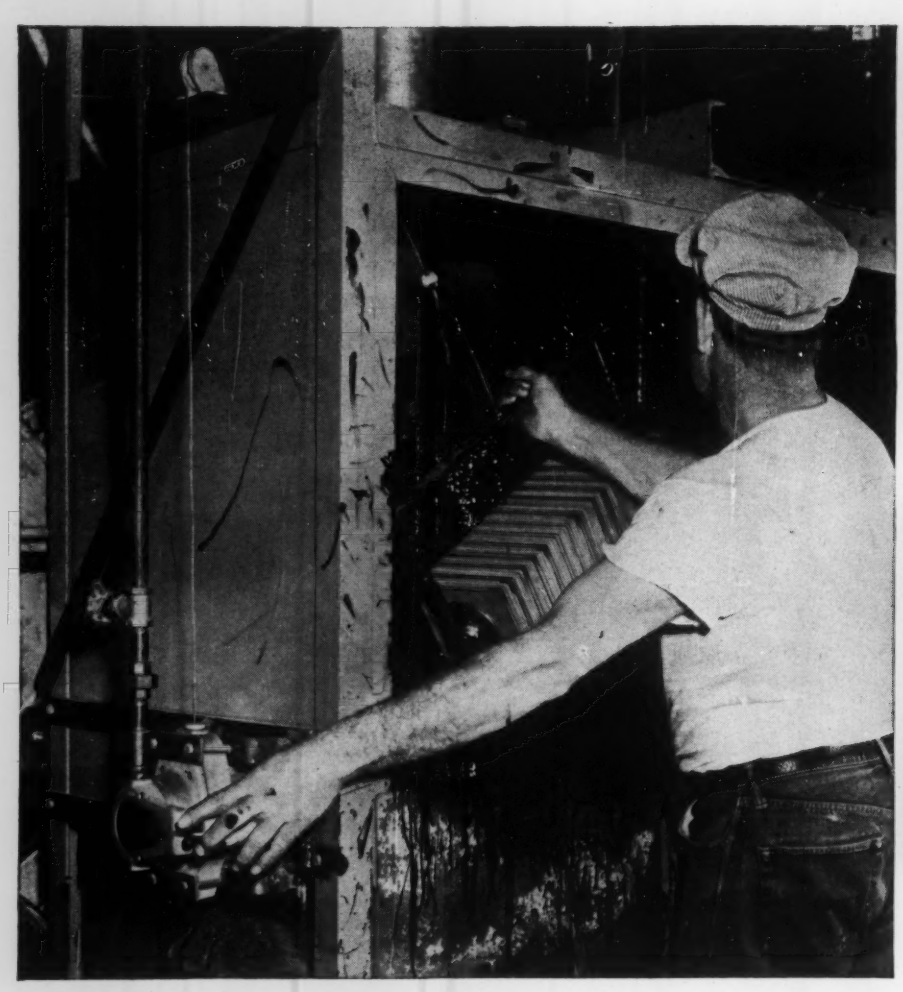
Square D Safety Switches cost no more —why settle for less?

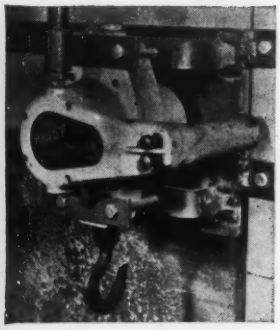
DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

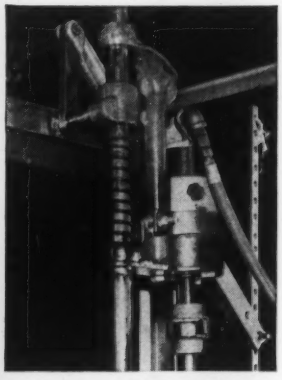
SQUARE D COMPANY

Circle 448 on page 19





Keller Tool 86A-1 air hoist —push-button controls give instant commands to hoist's reversible air motor.



Keller Tool 70A-26 air motor —powers spinner shaft, dries unit enough for handling, smooths out and gets rid of excess insulation.

New application of air hoist simplifies dipping operation

This manufacturer engineered an unusual method of insulating welding rectifiers by using the Keller Tool 86A-1 air hoist as an air-powered winch.

Bolting the hoist to the outside of the dip tank keeps the power unit away from the fluid in the tank. The climbing cable runs up and over two pulleys to carry the load during lifting and dipping operations. Push-button controls allow finger-tip manipulation of power and give the operator a free hand to guide the unit.

After dipping, the rectifier unit is pivoted to an air-powered spinner shaft at the right of the booth for drying. Air power makes the entire job fast, clean and simple.

Keller air tools are idea tools—versatile tools for industrial use. For information on the versatile 86A-1 air hoist (capacity, 150 lbs.), write for Bulletin 86.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

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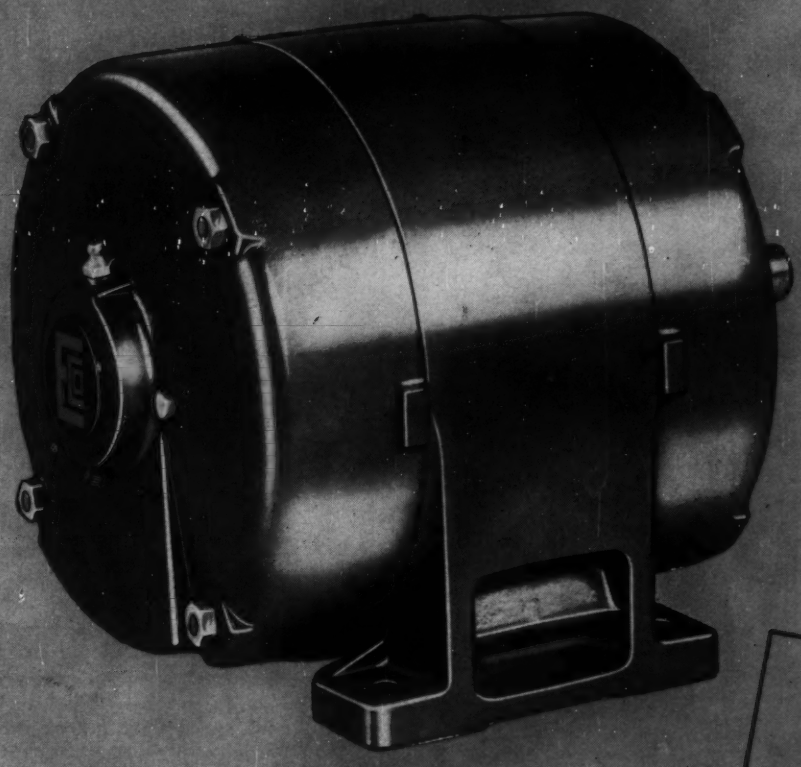
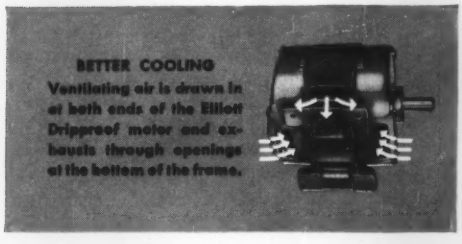
Inside and Outside . . . entirely new



DRIPPROOF TYPE FRAMES 182-326U

the NEW Elliott C-W Dripproof Motor

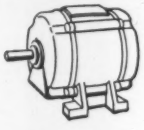
BALANCED DESIGN assures dependable performance


BETTER COOLING
Ventilating air is drawn in at both ends of the Elliott Dripproof motor and exhausts through openings at the bottom of the frame.

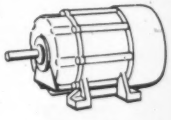
The *balanced* design of the new Elliott C-W type N motors provides the *best* in mechanical protection, the *best* in insulation, the *best* in bearings, the *best* in rigid construction. These motors produce more horsepower per pound, require less space, less maintenance, have longer service life. Every rotor is dynamically balanced. Rigid cast frames assure correct alignment, resist corrosion and mechanical abuse. Highly effective cooling eliminates troublesome hot spots.

The design illustrated above is dripproof—and virtually splash-proof as well. Yet ingenious design has provided ample passages for cooling air. Other types of enclosures providing even greater protection are available for service where conditions are extremely severe.

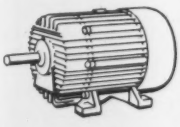
OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated



Totally-enclosed, fan-cooled Frames 256 U and smaller



Totally-enclosed, fan-cooled Frames 284U-326U

ELLIOTT Company

CROCKER-WHEELER DIVISION

For complete details, send for new booklet. *WRITE* Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

W6-5

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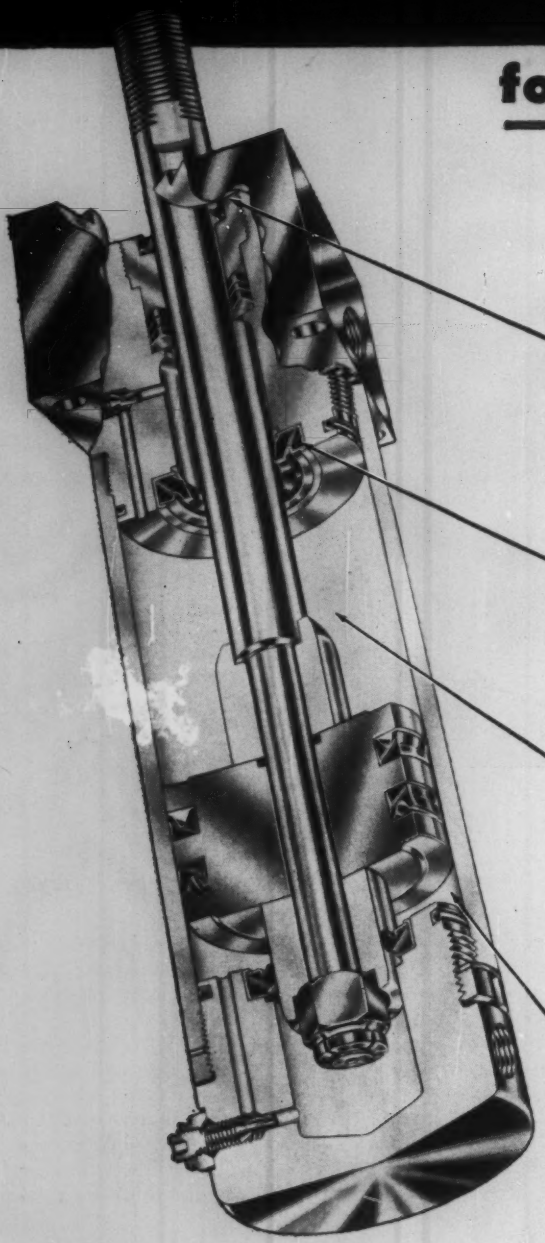
Need a cylinder today?

for all these Extras . . .

T-J Spacemaker



PISTON ROD SCRAPER . . . Not just a felt or fabric wiper, but a metal to metal contact. Protects rod packing and cylinder bores at all times by actually removing foreign particles from piston rod surface. STANDARD AT NO EXTRA COST!

NEW "SUPER" CUSHION FOR AIR . . . Of T-J design and patent, it assures millions of trouble-free cycles. Years of T-J research and test have answered the problem of "how to make a cushion last". All T-J cushions are adjustable, STANDARD AT NO EXTRA COST!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . The piston rod, of course. But of these two features, the chrome plated bore is by far the most important, due to the much greater area that is subject to wear. Chrome plating of bore gives extra protection where needed most. Also a protection from condensation and foreign matter, that may find itself into the system. STANDARD AT NO EXTRA COST!

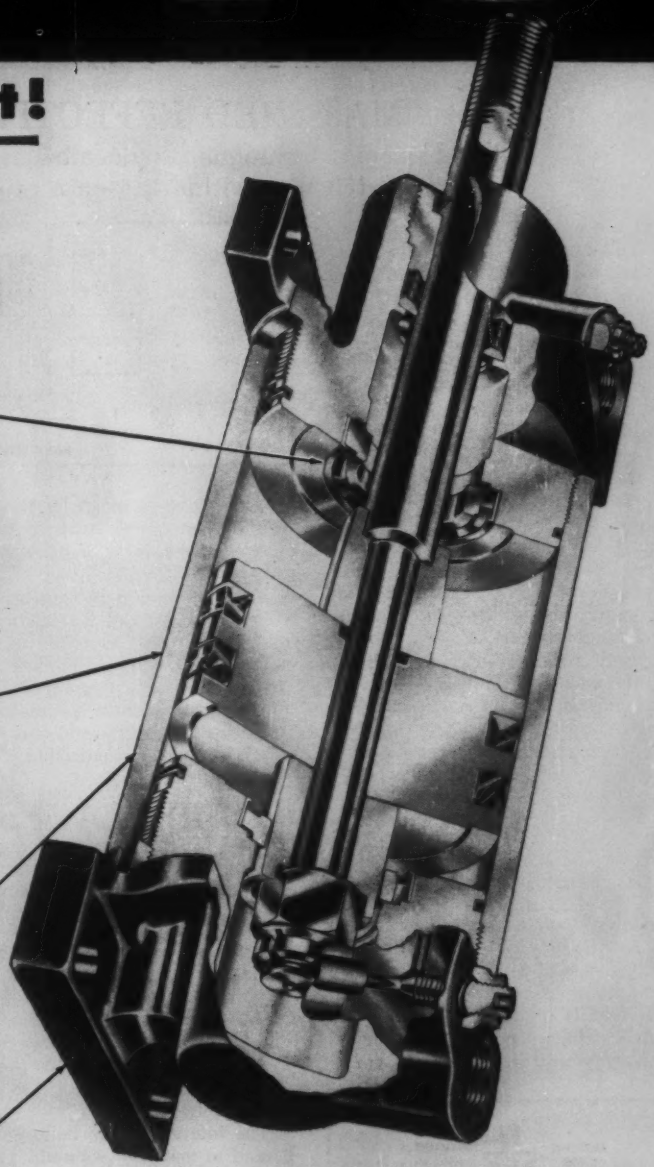
ONE PIECE PISTON . . . Giving you three point surface bearing which increases the distance from the piston end to the rod bearing. This T-J feature assures better alignment, longer bearing and packing life. STANDARD AT NO EXTRA COST!

off shelf delivery

. . . Just call T-J

at no Extra Cost!

cylinders



NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . (Pat. Applied For) New T-J cushion design eliminates problems of worn out, or out-of-line cushion seals. Eliminates need of a ball check while greatly increasing the return flow, assuring fast breakaway on return stroke. All T-J cushions are adjustable, STANDARD AT NO EXTRA COST!

NO TIE RODS TO STRETCH . . . By eliminating tie rods, the T-J SPACEMAKER gives you 360 degree port rotation, streamlined design, no tie rod stretch, without sacrificing strength. STANDARD AT NO EXTRA COST!

STREAMLINED DESIGN . . . Minimum center-line to center-line mounting—years ahead and in keeping with modern trends. Easy to clean for an extra appearance on your machine, without sacrificing strength. Oil pressure to 750 P. S. I.—air to 200 P. S. I. STANDARD AT NO EXTRA COST!

FORGED SOLID STEEL HEADS . . . (4" bore through 8" bore) Requires no additional mounting brackets, because mounting holes are a part of the one piece solid forged steel head. Its design lends itself to smooth streamlined modern appearance. STANDARD AT NO EXTRA COST!

WRITE TODAY for new bulletin with complete details of the T-J Spacemaker line, or call Jackson, Michigan, State 2-0462.

MEMBER OF THE NATIONAL FLUID POWER ASSOCIATION

THE TOMKINS-JOHNSON CO.

JACKSON, MICHIGAN

RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . REAMERS . . . CUTTERS . . . CLINCHORS

Circle 451 on page 19

NEWS FROM FLEXONICS

BELLOWS RESEARCH AND DEVELOPMENT

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

MATCHED EFFECTIVE AREA

New Flexonics technique provides bellows with effective areas matched to within 2% on a production basis

One of the problems of pressure sensitive bellows actuated devices is compensation for changes in atmospheric pressure. Flexonics Corporation has solved this problem with assemblies of bellows of matched effective area.

As indicated in Figure 1, the twin bellows are opposed mounted in a frame. The motor bellows is connected to the fluid system in which pressure is to be measured or controlled. However, this bellows is also affected by changes in external or atmospheric pressure. The compensating bellows, being sealed and completely evacuated is affected solely by the same changes in atmospheric pressure.

By joining the bellows and mounting them in a restraining frame, changes in atmospheric pressure will cause the motion of the two bellows to oppose one another. In the case of reduced atmospheric pressure, for example, the extension caused in the motor bellows is offset by the extension of the compensating bellows thereby maintaining a constant control point.

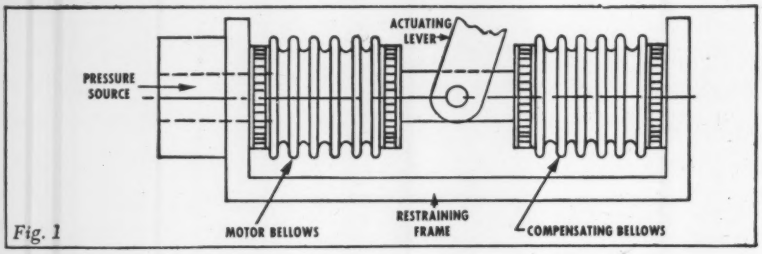


Fig. 1

Since force equals pressure times the effective area of the bellows, it is obvious that the secret of successful compensation is based on close matching of bellows effective areas. At Flexonics, effective areas are matched to within 2% in actual production. Spring rate is also closely controlled.

Such balanced performance is necessary for precision control of fuels, gases, air, pressure differentials, mixture of elements or ingredients and multiple recording devices under varying environmental conditions. Linkage may be achieved in a variety of ways to operate valves, rheostats, switches, dial indicators, needle jets or weights.

Further information is available on request. Send an outline of your requirements.

BELLOWS REPLACES CLUTCH

Unique application of Flexon Bellows in flow control valve serves to vary compressor load as demand changes

A bellows operated valve made by John E. Mitchell Co., Dallas, Texas, manufacturers of Mark IV automobile air conditioners, serves to replace a clutch that is required in other conditioners. The purpose of the clutch is to engage and disengage the compressor according to demand on the system and varying engine speed.

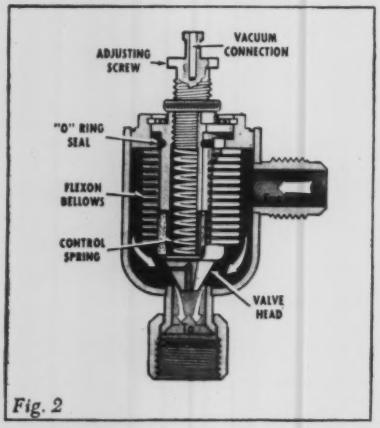


Fig. 2

Varying engine speed results in varying compressor speed and consequently in varying refrigeration effect. The Mitchell bellows-operated Robo-Trol valve compensates for the speed variations by controlling the rate of flow of refrigerant.

The interior of the bellows is connected to manifold vacuum. Thus the internal bellows pressure is higher at high speeds than at low speeds. Refrigerant at suction side pressure exerts force on the exterior of the bellows. The resultant pressure differential, directly related to engine (and compressor) speed governs the degree of opening of the valve.

Varying system demand is reflected in varying suction side pressure (the greater the demand, the higher the pressure) so the valve also adjusts flow in response to the requirements of the system.

Here is another good example of how Flexon Bellows can be used to do a control job more efficiently and more effectively. If your design requires pressure or thermostatic actuation or control investigate the advantages of Flexon Bellows or Bellows Assemblies. Just send an outline of your requirements.

Flexonics *Corporation*

BELLOWS DIVISION

1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Circle 452 on page 19

Ready, Set, GROW...with

For aluminum tube that is right for its purpose and comes to you right on schedule, call the nearest Revere Sales Office. Revere is headquarters for tube . . . seamless drawn, welded, lockseam and other types, in an extensive range of sizes, alloys and tempers, both round and other than round. It will pay you to tie the growth of your business to the most dependable sources of supply. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include coiled and flat sheet, both plain and embossed, circles and blanks, Tube-In-Strip,* extruded products, all types of tube, rolled shapes, electrical conductors, forgings, foil, and frozen food containers. *Revere's trademark for sheet metal containing inflatable channels.

Circle 453 on page 19

Seeburg designers choose P-K® screws

to match the fastener to the job!

Joseph Kamys, engineer, J. P. Seeburg Corporation, Chicago, manufacturers of coin operated phonographs says, "Seeburg standards demand attention to every detail—quality workmanship and materials throughout. With Parker-Kalon screws, we can match the fastener to the specific application—be sure of dependable results."

Attachment of metal base molding and kickplate to a Seeburg cabinet, in a metal-to-wood application. "Rather than use ordinary wood screws, we power-drive P-K Self-tapping Type-A," says Mr. Kamys. "Holding power is far better, there's less chance of wood splitting, and fewer rejects at inspection."

Here, metal rims of two high-frequency speakers are fastened to a formed, one-piece, plastic housing. "In this metal-to-plastic application we have not only the problem of possible plastic breakage, but the fastener used must be highly resistant to vibration. We find P-K thread-forming Type-Z screws highly satisfactory."

If you are designing a new product or new model, it will pay you to talk with a Parker-Kalon Field Engineer. He can help in the selection of proper fasteners, can often suggest ways to speed production—cut costs. You can contact him through your local Parker-Kalon Industrial Supply Distributor.

***PARKER-KALON DIVISION,** General American Transportation Corporation, Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.*

Sold Everywhere Through Leading Industrial Distributors. Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois, Los Angeles, Calif.

PARKER-KALON®
fasteners

Wherever your machinery is shipped...

the performance and the name are the same around the world!

FOR YEARS SHELL TELLUS OIL has been top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat foaming, oxidation, rust, sludge-formation and wear has earned it nation-wide popularity.

You may be glad to know that the equipment you manufacture can get the same efficient protection in foreign countries. Tellus* Oil is available to your foreign customers from near-by points. It will be the same Tellus Oil that your domestic customers rely upon. Write Shell Oil Company, 50 West 50th St., New York 20, New York, or 100 Bush Street, San Francisco 6, California.

*Trademark

Machinery manufacturers:
Your customers abroad will receive the same Shell Tellus Oil that your domestic customers enjoy. And this same uniformity applies to

SHELL TURBO OIL—gives anti-wear lubrication for utility, industrial and marine turbines

SHELL ALVANIA GREASE—multi-purpose industrial grease, and a complete line of other

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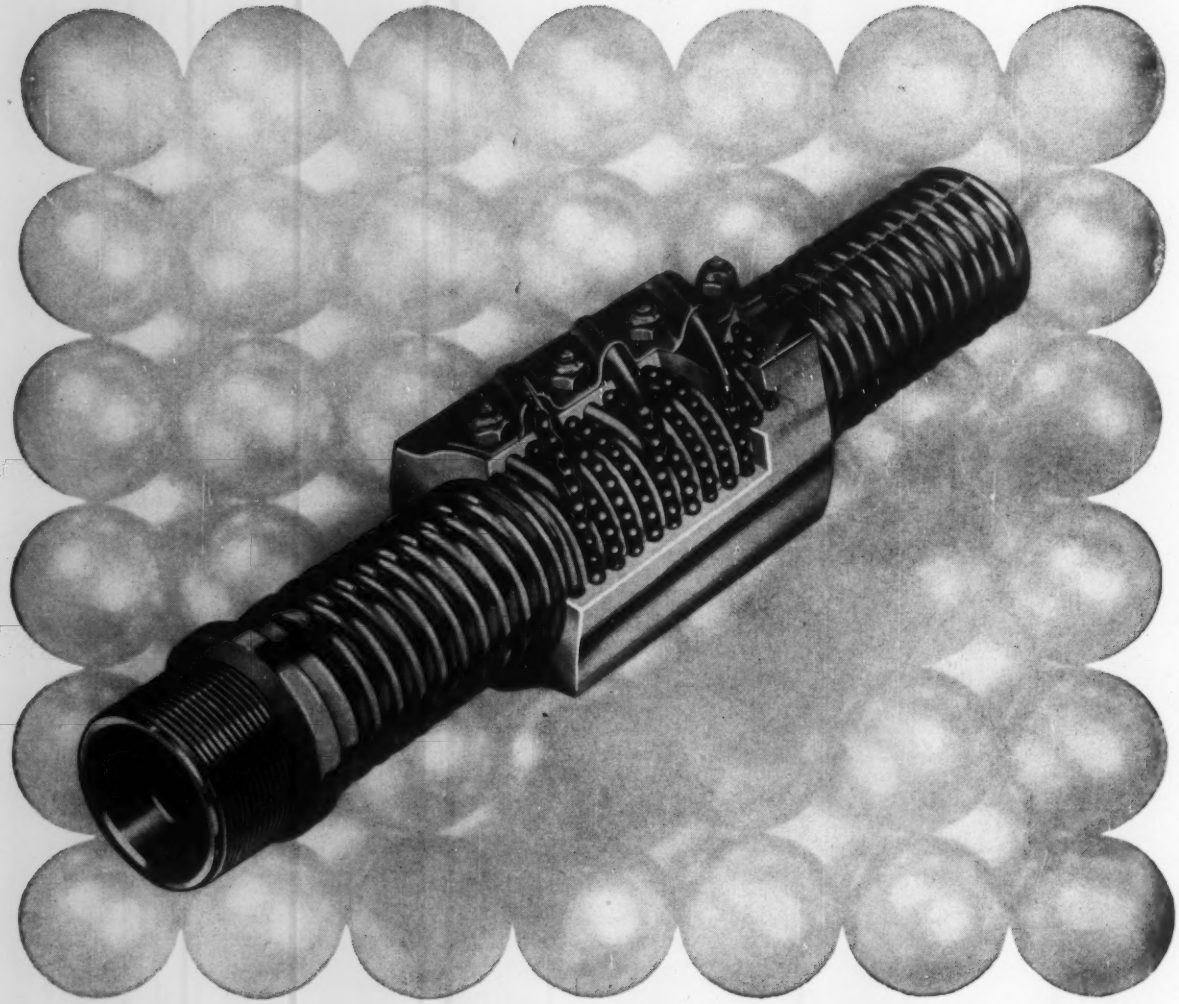
Circle 455 on page 19



how Vacuum Metals' FERROVAC boosts ball bearing screw life up to 400%...

Ball bearing screw assemblies, first used in automobile steering mechanisms, are now found in such critical applications as the actuation of landing gear and control surfaces of aircraft and guided missiles. And it was in tough jobs like these that the assemblies failed in fatigue. Then a leading manufacturer tried vacuum-melted FERROVAC® for the balls – and service life rose as much as 400% over the original life. Here's why...

Vacuum melting improves fatigue properties – It literally sucks gaseous impurities – focal points for fatigue failure – from the molten metal. Vacuum-melted metals are cleaner, purer, tougher. And cleanliness means an added bonus in fewer rejects.

Only Vacuum Metals gives you one-source service – Vacuum Metals Corporation, Division of Crucible Steel Company of America, provides a fully integrated service from melting and casting through mill rolling and nationwide distribution of finished mill products. And you can get not only small experimental lots, but now, thanks to our new 2500 lb. induction furnace – the nation's largest – you can also get large-scale continuous production quantities of vacuum-melted metals. If you have an application which these unique metals may improve, please write giving full details. *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, New York.*

VMC®

VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

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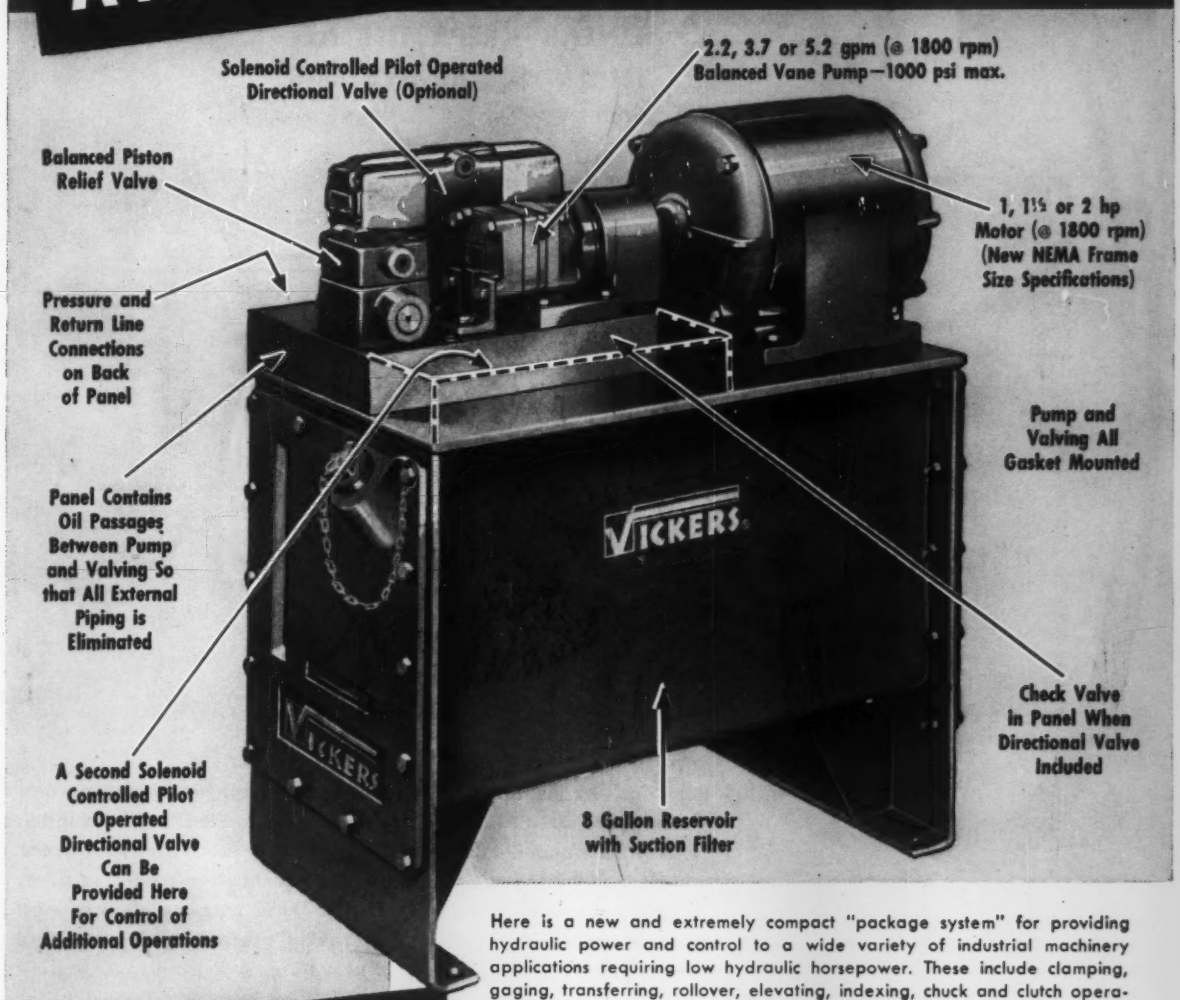
A NEW IDEA . . . in hydraulic power and control systems


Solenoid Controlled Pilot Operated Directional Valve (Optional)
2.2, 3.7 or 5.2 gpm (@ 1800 rpm) Balanced Vane Pump—1000 psi max.
Balanced Piston Relief Valve
1, 1½ or 2 hp Motor (@ 1800 rpm) (New NEMA Frame Size Specifications)
Pressure and Return Line Connections on Back of Panel
Pump and Valving All Gasket Mounted
Panel Contains Oil Passages Between Pump and Valving So that All External Piping is Eliminated
Check Valve in Panel When Directional Valve Included
A Second Solenoid Controlled Pilot Operated Directional Valve Can Be Provided Here For Control of Additional Operations
8 Gallon Reservoir with Suction Filter
VICKERS

VICKERS®

Series T8

HYDRAULIC PIPELESS POWER PACKAGE*

7311

Here is a new and extremely compact "package system" for providing hydraulic power and control to a wide variety of industrial machinery applications requiring low hydraulic horsepower. These include clamping, gaging, transferring, rollover, elevating, indexing, chuck and clutch operations, etc.

Note the many features indicated on the photograph above. The result is improved and simplified hydraulic design . . . also reduced installation and maintenance costs. This "package system" has great flexibility . . . is available in a wide variety of combinations of standard components assembled to suit individual requirements. Pretested and ready for immediate operation, it has also the advantage of undivided Vickers responsibility. For further information, ask for installation drawings 178706-8.

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

Machinery Hydraulics Division

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Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N. J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER

IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

*These "package systems" supplement the Vickers line of standard hydraulic power units.

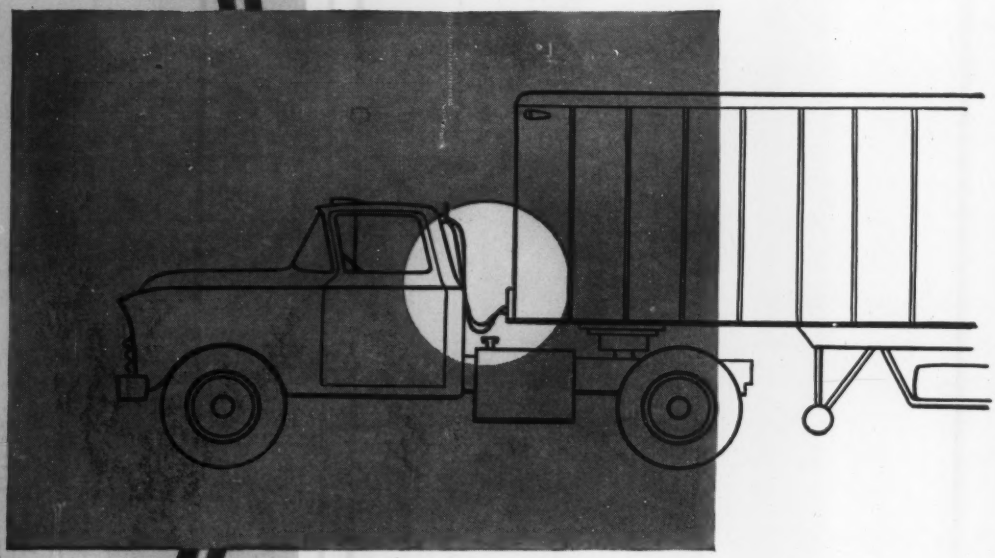
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 457 on page 19

. . . for greater dependability . . . LONGER

LINEAR KEEPS THE AIR IN AIR BRAKE SYSTEMS

with Roto-Mold "O" Rings



Big "rigs" of the open road have to have air-brake systems that stand guard at all times. There's no room for leakage or sudden failure. To transmit this braking power from cab controls to rear wheels, yet enable easy separation of tractor and trailer, requires flexible hoses with quick disconnects. These coupling devices must have a positive seal, withstand braking pressure and mechanical abuse, yet connect or disconnect with ease.

LINEAR'S ability to produce precision "O" rings—fast and economically—has provided safe, positive seals for airhose couplings . . . to keep the air in air brake systems. The exclusive Roto-Mold process assures physically better seals . . . dimensionally stable . . . free from foreign inclusions and flash.

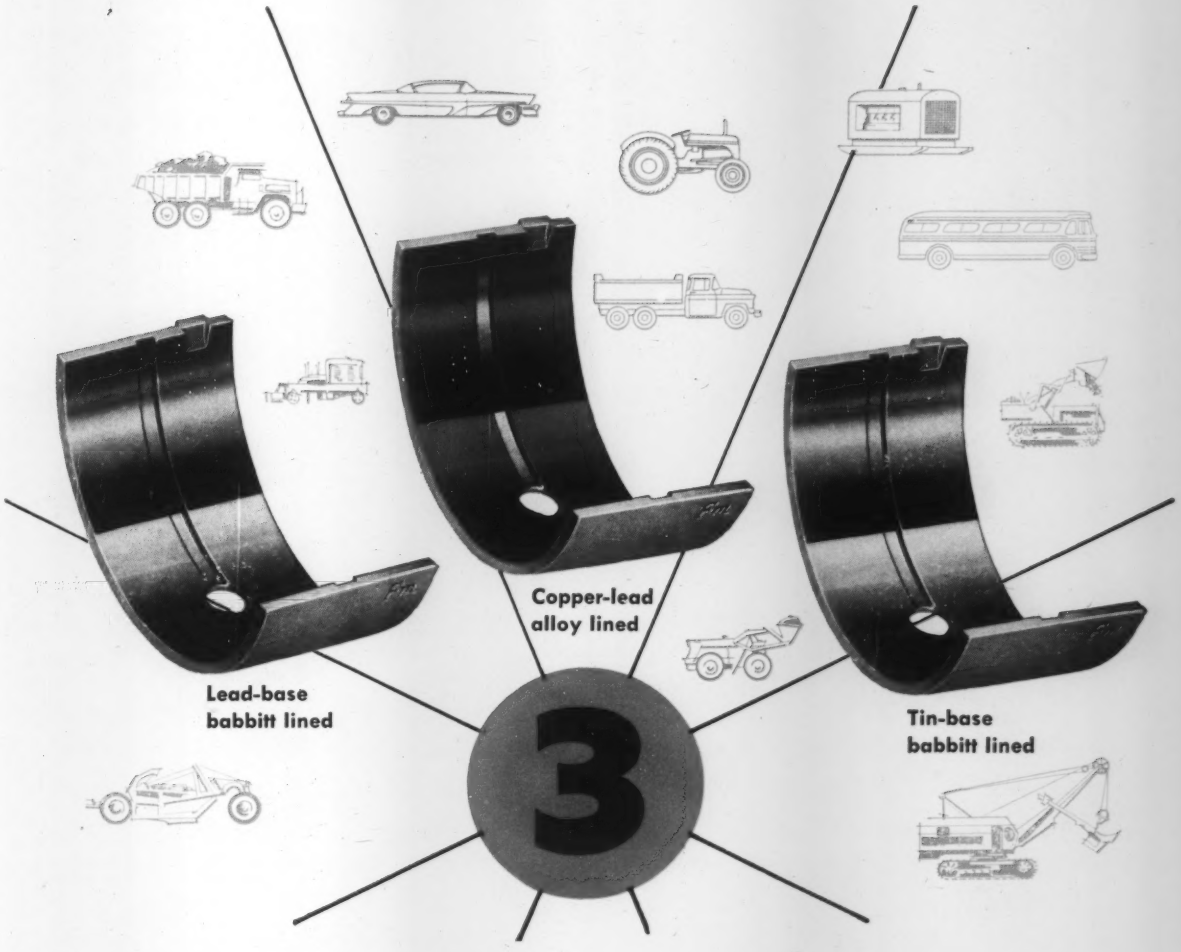
No matter what your sealing problem may be—call on LINEAR or one of its agents for engineering assistance . . . and be sure to specify LINEAR Roto-Mold "O" Rings.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 458 on page 19



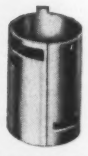
bearings that meet the widest range of engine applications

Across the broad range of engines which impose light or medium loads on the bearings, tin-base and lead-base babbitt-lined bearings are the economical, dependable "work horses". For the newer engines imposing heavy loads, bearings lined with copper-lead alloy are the answer. Using our patented, low oxide copper-lead powder alloy as the heart of the lining, steel-backed copper-lead bearings produce new performance standards in heavy-duty operation. For complete information address:

FEDERAL-MOGUL DIVISION

Federal-Mogul-Bower Bearings, Inc.

11045 Shoemaker, Detroit 13, Michigan



Rolled, Split Bushings

Bimetal Bushings

Spacer Tubes

Bearing-surfaced Thrust Washers

FEDERAL Mogul

SINCE 1899

RESEARCH · DESIGN · METALLURGY · PRECISION MANUFACTURING

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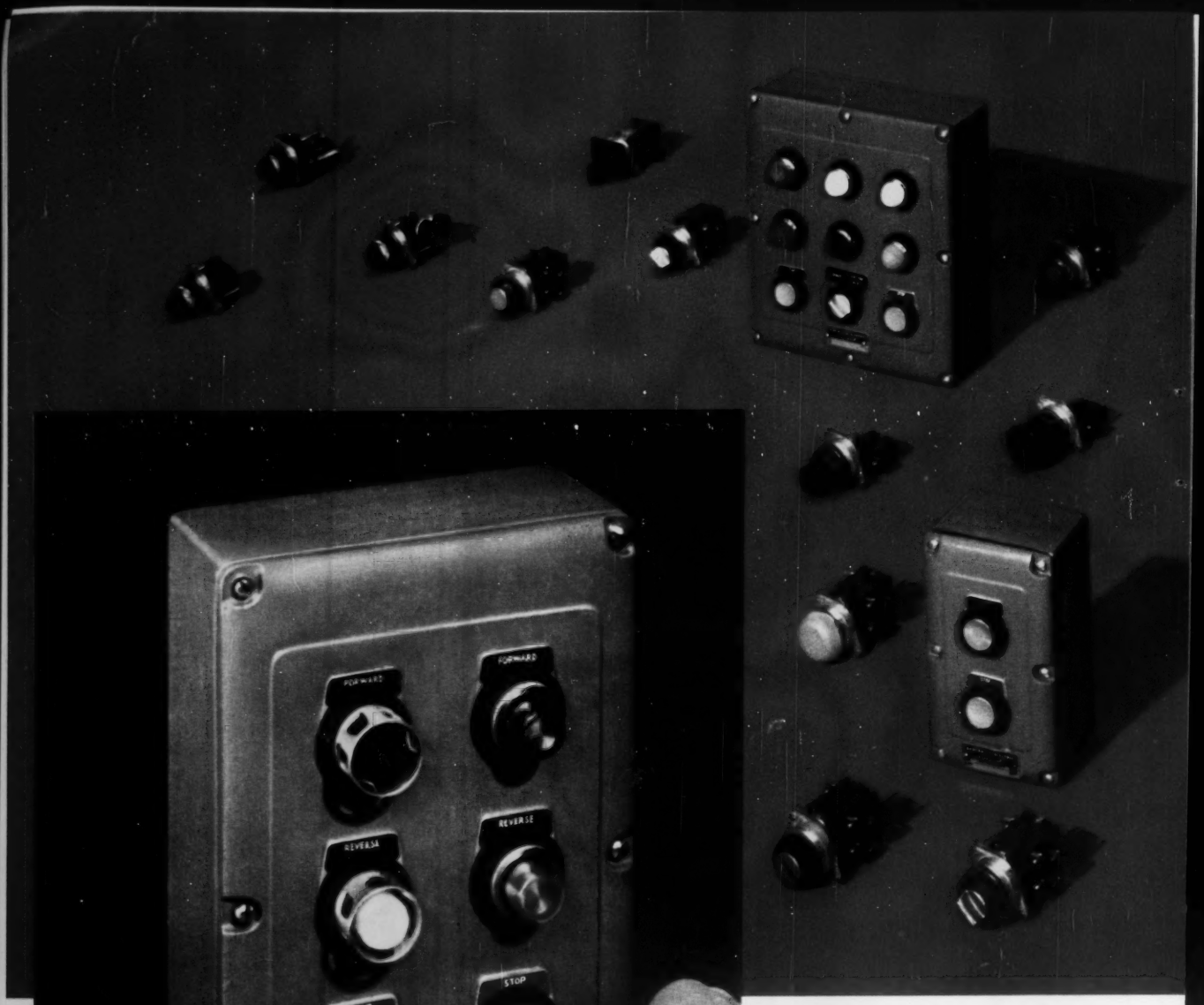
Circle 460 on page 19→



ILLUMINATED
PUSH BUTTON

PUSH TO TEST
INDICATING LIGHT

OIL-TIGHT PUSHBUTTON LINE

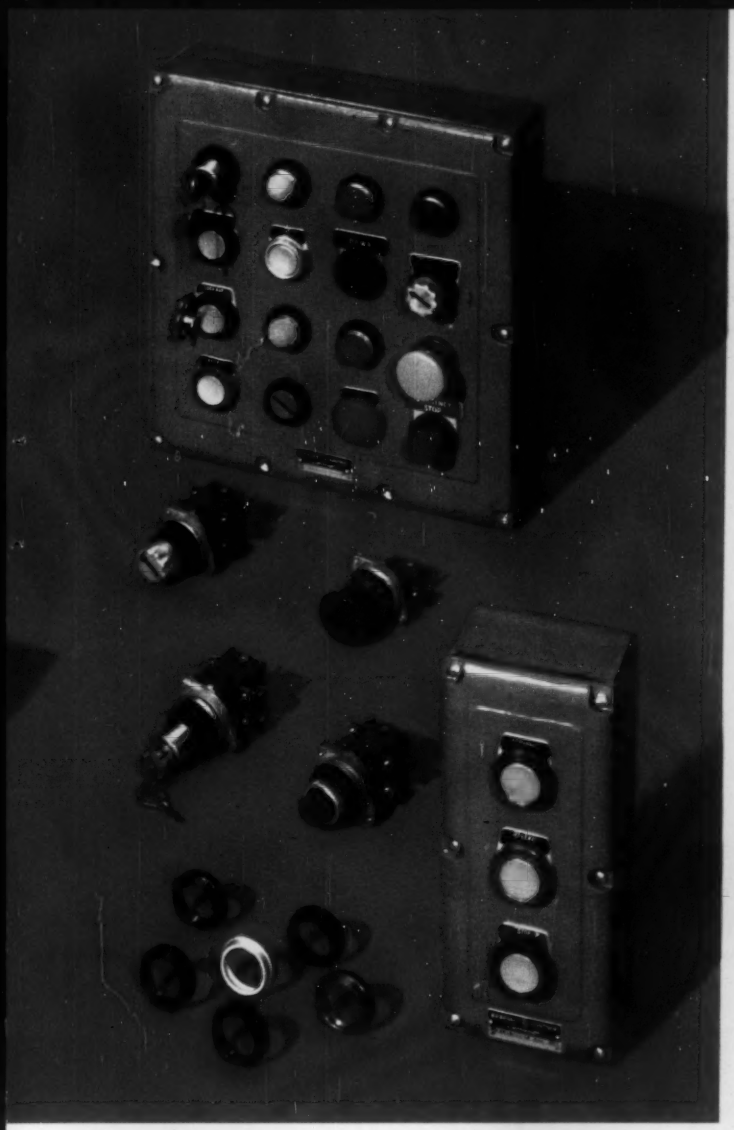
General Electric's oil-tight line includes: standard and mushroom-head buttons; selector switches and potentiometers; indicating lights in six colors; and other special operators. Stations are available to accommodate one to sixteen units.

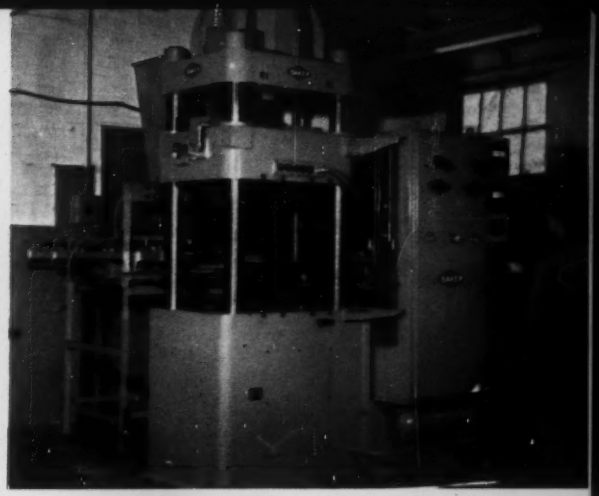
ILLUMINATED PUSH BUTTON

Color caps are available in red, green, amber, white, blue and clear. Units can be furnished with guard (left on station). Transformers are available rated 110, 220 volts, 50/60 cycle or 440 volts, 60 cycle.

PUSH TO TEST INDICATING LIGHT

Faceted lens provides greater dispersion of light and gives all-angle visibility. Forms are available with the same transformer ratings and with the same six lens colors as the illuminated button.





BAKER BROTHERS, INC., Toledo, Ohio, has standardized on General Electric oil-tight push buttons for their plastic molding presses. Units are front mounted on control panel door.

ONSRUD SPAR MILLING MACHINE—operated by G-E oil-tight push buttons in flush panels and a pendant station—is made by Onsrud Machine Works, Inc., Chicago, Illinois.

ADDED TO GENERAL ELECTRIC'S OIL-TIGHT PUSH BUTTON LINE, A...

NEW illuminated push button and a NEW push to test indicating light

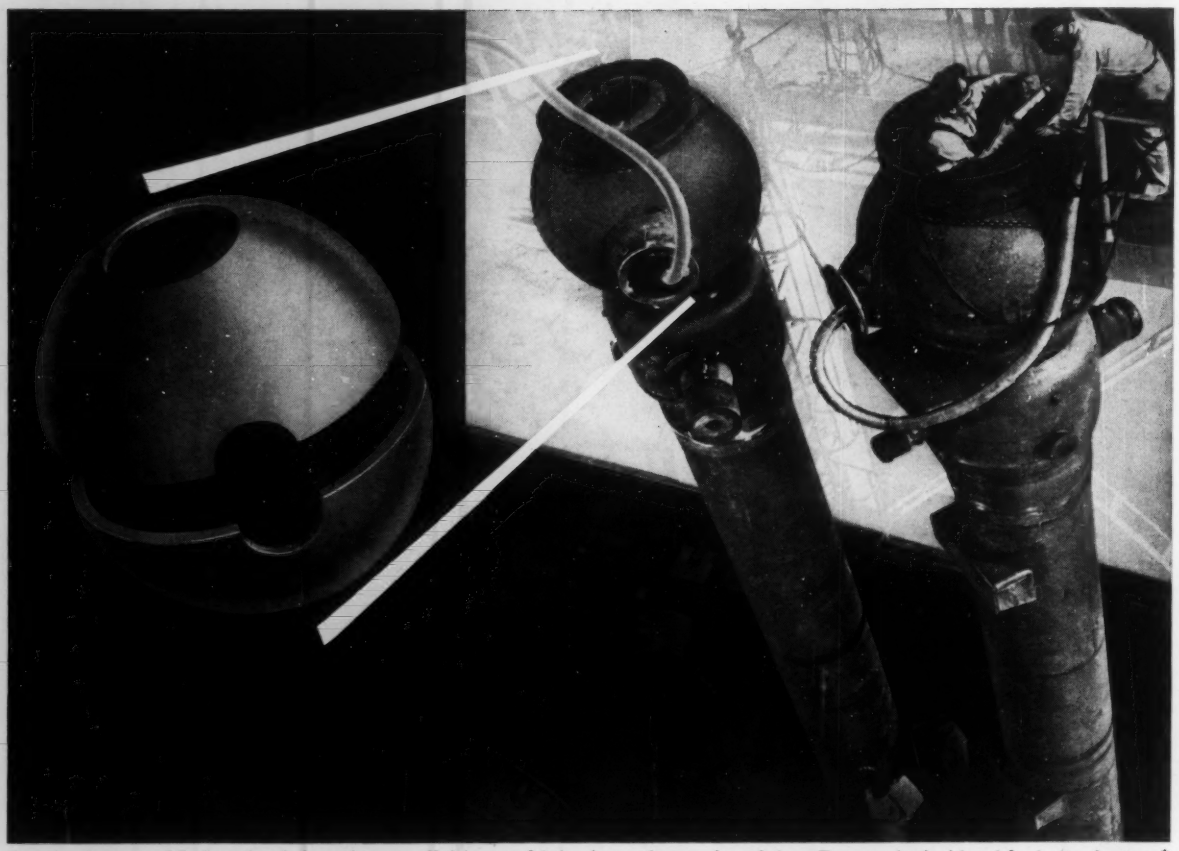
A new space saving illuminated push button and a quick-check, push to test indicating light have been added to the General Electric oil-tight pushbutton line. The illuminated push button is a single unit that provides the functions of both a push button and an indicating light, and can save you half your mounting area. The new push to test unit meets the newly revised JIC standards for push-to-test indicating lights. Both new units fit the same mounting hole and space as other units in the line.

BOTH NEW UNITS are furnished with one standard contact block, and a permafil encapsulated transformer with the bulb mounted on the front. The encapsulating material helps insulate the transformer windings, and provides additional strength and resistance to mechanical damage. The bulb is the new plug-in G-E No. 12, 6 volt lamp, which has extremely long life.

FLEXIBILITY in selection is one important feature of the entire General Electric oil-tight pushbutton line. Building-block construction allows you to use the same contact block with all separable operators, color rings and nameplates. Indicating lights, special units and accessories complete the line to give the many combinations you need.

FOR DETAILS of the new units and the complete oil-tight line, see your nearest General Electric Apparatus Sales Office or Distributor. Or, write for bulletin GEA-5779, Advertising Section 731-12, General Electric Co., Bloomington, Illinois.

GENERAL ELECTRIC



Imaginative use of Lukens heads brought new efficiency to fabrication and operation of these Braun spherical head feedwater heaters.*

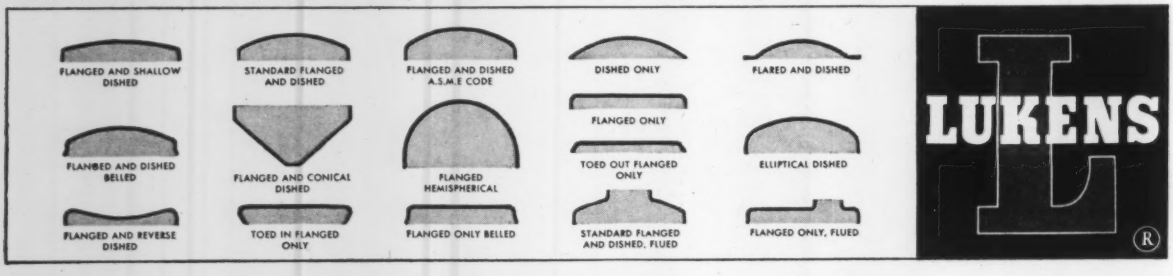
Now you can simplify . . . and save . . . designing with Lukens heads

Here's practical imagination at work—C. F. Braun & Co.'s new spherical head feedwater heaters.* Each sphere is fabricated from two Lukens standard hemispherical steel heads. The benefits: High reliability . . . elimination of all flanges and bolted gasket joints . . . the ideal simple shape for economy of material and fabrication.

Fabricators of heavy and light machinery, valves, wheels, to name a few, have also benefited from imaginative use of Lukens heads. They've lowered costs, improved quality, streamlined fabricating methods. Lukens' fifty-five years as the leading producer of spun and pressed steel heads for many applications are at your service. Write for Catalog 936, *"Pricing and Engineering Data."* Lukens Steel Company, Coatesville, Pennsylvania.

*Patents Pending

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels



The story of plus value in Roller Chain...

written on the end of a pin

To provide the long wear life and fatigue resistance you expect from a roller chain, the pins *must* have two characteristics:

One... a case-hardened surface for longest wear life plus a tough, resilient core for shock load resistance.

Two... comparatively soft ends for secure riveting and maximum holding power in the link plates.

How can you have these two opposites in one pin?

In Rex Roller Chains, the pins are completely copper-plated. Then, the copper is ground off only the pin body, leaving the pin ends plated. Next, they're carburized in controlled-atmosphere gas furnaces. Since copper will not absorb carbon during heat treatment, the pin ends are not hardened... remain relatively soft. The pin body gets the file-hard case depth you need.

Look for the *copper-plated pins* before you buy roller chain. They're visible evidence of the *plus* value in Rex Roller Chains. For the story on the "finest roller chains made," mail the coupon. CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT

Leadership... through creative engineering

CHAIN Belt Company
4643 W. Greenfield Ave., Milwaukee 1, Wis.
☐ Send me my copy of Catalog No. 610.
☐ Have CHAIN Belt Man call.

Name.....

Company.....

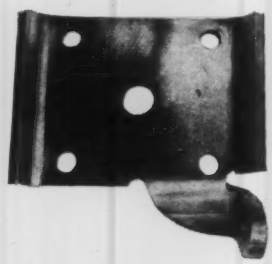
Address.....

City.....*Zone*.....*State*.....

Circle 462 on page 19

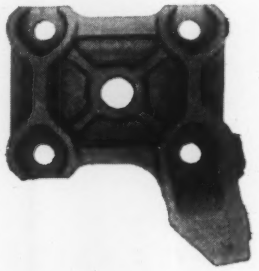
Why this particular rear spring bracket becomes important to all manufacturers

In itself, the ArmaSteel spring bracket described here is of small interest except to the automobile manufacturer for whom we made this study. But this bracket becomes significant as a typical example of what is being done—what can be done—here at Central Foundry Division to increase strength, reduce weight, and reduce the cost of many types of parts by means of relatively new stress analysis testing techniques.



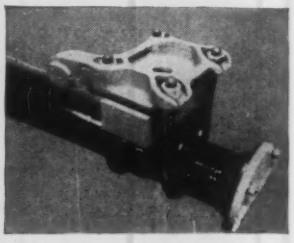
1

The steel stamping for the rear spring bracket (clip pad) of a popular passenger car. ● Made from .438 stock, S.A.E. #1015 steel, the part weighs 4.2 pounds. From this, a casting is to be evolved with these specifications: 800 pounds maximum push or pull load on shock absorber ear, 75 foot-pounds assembly torque load on each U-bolt lock nut.



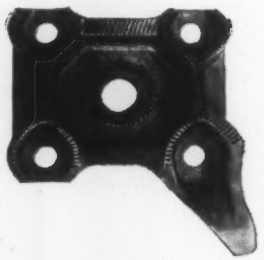
2

Cast design no. 1 is created. ● Already slightly lighter in weight (4 pounds) than its stamped counterpart, this version is submitted for stress analysis. Preliminary tests indicate this casting is overdesigned. The unnecessary ribs can be eliminated, shock absorber ear can be tapered, and a second, lighter design is evolved, weighing only 3.25 pounds.



3

Testing. ● Using a production axle, each casting design is fastened on over rubber pads. The insertion of a steel block duplicates spring thickness. Production U-bolts and lock nuts are also used to duplicate actual loading conditions and torque characteristics.

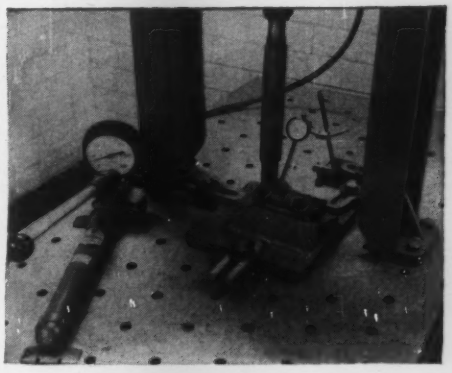


4

The stress pattern on casting is established. ● Using brittle lacquer, the areas of highest stress concentration are determined so that casting weight can be further reduced without reducing the strength of the part.

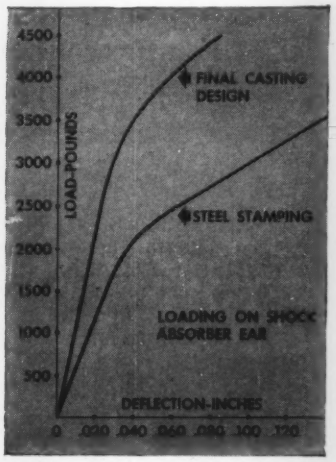
5

The 4th and final design. ● Now weighing but 2.90 pounds, the fourth version is fastened to the test device's loading fixture (shown at right) to test the shock absorber ear for deflection and yield points. This revised version proves the value of stress analysis by sustaining nearly 3,000 pounds load (yield point) at less than 0.30 inches deflection—almost 2,200 pounds ABOVE the auto manufacturer's specifications! *Only now* will the tested design be submitted for approval.



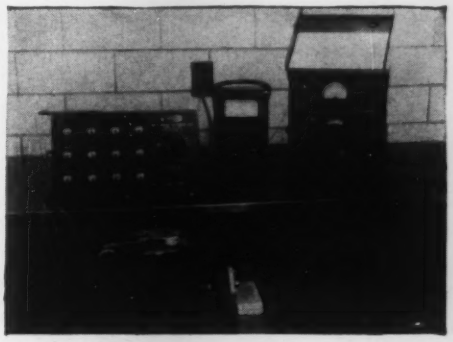
6

Testing shock absorber ear on casting for Deflection and Yield Point. ● The casting was fastened to the loading fixture simulating actual loading conditions using rubber pad and steel block, and load increments were applied on the shock absorber ear.



7

Stress analysis helped create a stronger casting design. ● Above graph illustrates the improved strength and rigidity of the casting over the stamping.



8

Even the actual load on U-bolts was determined. ● Strain gauges, as shown above, were fastened to U-bolts, and strain readings were made at required torque. The bracket, as it finally evolved, assured the auto manufacturer that the final design was without inherent weakness.

Just as we helped this manufacturer to produce a better bracket at lower cost so, too, can our research department assist you by means of the latest equipment and processes including stress-analysis, Cobalt 60, Radiography, Spectrochemical analysis and Sonic testing. Brief descriptions of these and many other phases of modern casting methods are contained in the new book, "SHELL CASTING AT CENTRAL FOUNDRY".

Write for free copy of new "Shell Casting" catalog, today.

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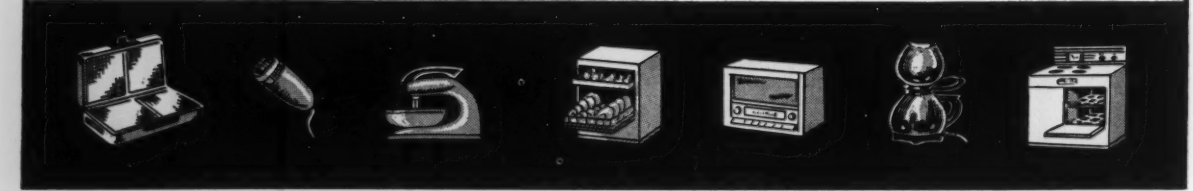


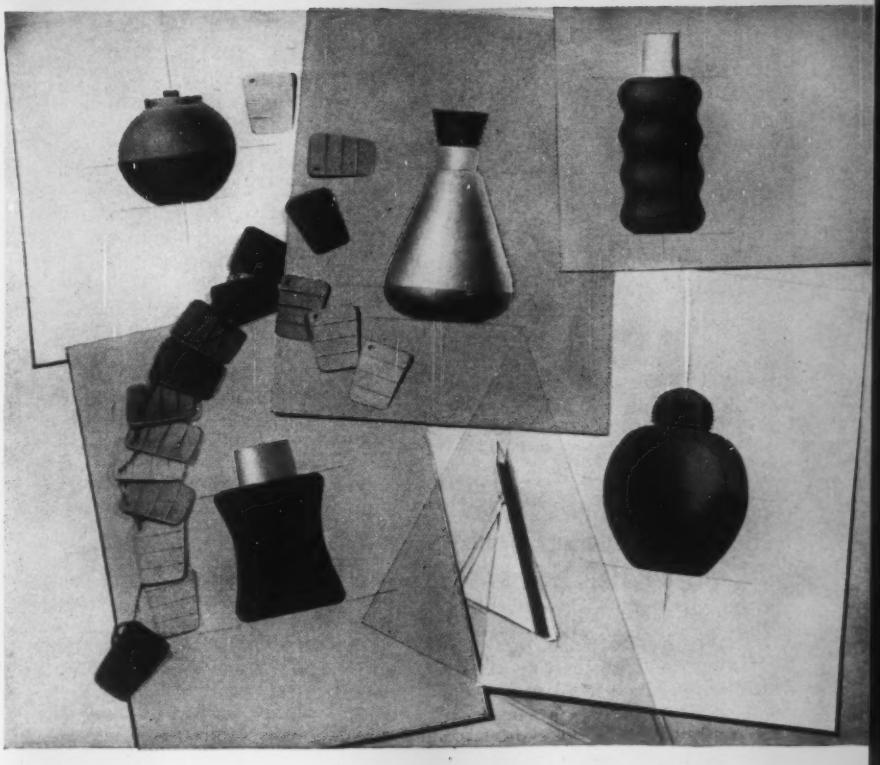
DU PONT

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS:

ZYTEL®, TEFLON®, LUCITE®

Now, aerosol packages in colorful, new designs with ZYTEL® nylon resin



A new grade of ZYTEL nylon resin and a new fabricating technique are responsible for the entrance of Du Pont ZYTEL into the aerosol packaging field. Now products can be marketed in aerosol packages which have exciting new shapes and attractive built-in colors.

The new grade of ZYTEL, type 42, is more viscous when melted . . . can be extruded easily in a form suitable for blow molding. Therefore, the use of ZYTEL permits an increased variety of functional and attractive designs.

The new technique of welding two injection-molded sections of ZYTEL permits the designer to vary his pigments and create eye-catching aerosol packages in a combination of beautiful colors.

Aerosol packages of ZYTEL have a special appeal in the personal products field for colognes, hair lacquers and anti-perspirants. ZYTEL is impermeable to propellents . . . inert to chemicals found in many personal products. And because of the remarkable strength of ZYTEL nylon resin, the pressurized containers do not shatter, even when they are dropped on hard bathroom floors.

Property and application data on ZYTEL are available to you without cost or obligation. To get this information, simply clip and mail the coupon on the next page.

AUTOMATIC ELECTRIC PENCIL SHARPENER wears longer and operates more quietly due to its sturdy parts of ZYTEL nylon resin. Components of ZYTEL, such as the combined gear and bearing shown above, often replace complex metal assemblies without sacrifice in strength. In this way, ZYTEL helps to eliminate casting, machining, grinding and other operations that add to costs. Little or no lubrication is required for mechanical parts of ZYTEL. (Parts molded by The Ark Inc. for Stile-Craft Manufacturers, Inc., both of St. Louis, Missouri.)

BEARING SEALS of TEFLON tetrafluoroethylene resins are vital design features of the Floco Meter, assuring trouble-free performance. Used to measure the flow of crude oil, the meter requires a minimum of attention and maintenance. The bearing seals are unaffected by petroleum chemicals, temperature of the flowing oil, and suspended abrasives such as sand and grit. Waxes in the oils do not adhere to the surface of TEFLON, so that clogging is prevented. (Manufactured by Flow Equipment Company, Inc., Los Angeles, Calif.)

Circle 465 on page 19

PUMP ROLLERS of ZYTEL nylon resin are unaffected by the insect, weed and cattle sprays or liquid fertilizers handled by this pump. A stainless-steel core is molded directly into each roller of ZYTEL. The rugged rollers resist wear at high pump pressures, even when handling liquids containing wettable powders. The heavy-duty pump slips directly onto tractor take-off shaft. (Rollers molded by Minneapolis Plastic Molders for Hypro Engineering Company, both of Minneapolis, Minnesota.)

OVER

DU PONT

REG. U.S. PAT. OFF.

PRODUCT ENGINEERING NEWS

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: ZYTEL®, TEFLON®, LUCITE®

Because it is made of durable Du Pont LUCITE, the fashionable "Lady Schick" electric shaver will retain its sparkling, jewel-like appearance for years. (Molded and decorated by Hoosier Cardinal Corp., Evansville, Ind., for Schick, Inc., Lancaster, Pennsylvania.)

Beauty and durability of Du Pont LUCITE® lend sales appeal to "Lady Schick" shaver

Attractive, durable and economical, LUCITE acrylic resin is being used to add sales appeal to a wide variety of products. The "Lady Schick," for example, a new electric shaver for women, is exquisitely styled in sparkling LUCITE. And because of the remarkable strength and durability of LUCITE the shaver will retain its attractiveness for years.

Economically molded, LUCITE is used extensively in smartly styled appliances, household items and personal articles of all kinds. Because of its remarkable resistance to weathering and its outstanding optical properties, LUCITE also plays an important part in the lighting and sign industries.

Why not investigate LUCITE in terms of your own operation? To help you evaluate this remarkable material, we have prepared data that is yours without cost or obligation. Simply clip and mail the coupon below, and this information will be on its way to you.

Gaskets and packings made of TEFLON® resist corrosives tetrafluoroethylene resins and high temperatures

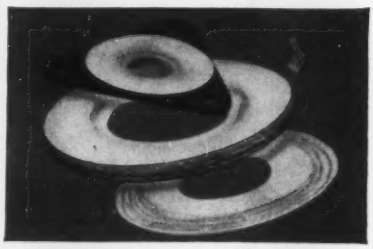
When you specify a TEFLON tetrafluoroethylene resin as the sealing material for your designs, you get the nearest approach to complete reliability for the majority of sealing conditions. You're sure that your seals aren't going to corrode or crumble under the attack of even the most powerful reagents. You're certain that you'll find your seals operating without failure at temperatures as high as 500°F. You're protected against any sign of seal embrittlement down to temperatures in the liquid-helium range. And you get the benefit of the low coefficient of friction of TEFLON resins, which greatly reduces torque at points such as shaft packing glands. Non-stick property makes it easy to open joints when necessary.

TEFLON tetrafluoroethylene resins are among the most inert chemical materials known to science. They are unaffected by nearly all chemicals and solvents in commercial use. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect them.

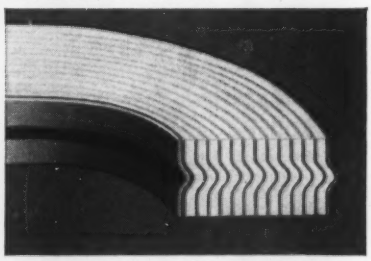
TEFLON resins are tough, flexible materials which can be accurately machined and molded. Most of the mechanical properties of solid TEFLON resins are comparable to those of the best grades of rubber-bonded compressed asbestos. High-pressure packing rings perform satisfactorily in 15,000 psi pumps. Seals, gaskets and packings of TEFLON tetrafluoroethylene resins operate reliably year after year, minimizing maintenance and replacement costs.

Send for the special literature we've prepared on this subject. It's packed with facts that can help you solve your sealing problems.

PACKINGS of TEFLON resins give uniform packing performance and long service life. Lubricity of TEFLON provides high mechanical efficiency.



ENVELOPE GASKETS consist of a soft filler covered by a jacket of a TEFLON tetrafluoroethylene resin. They are used for sealing large diameters and where bolting pressures must be limited, as in glass-lined equipment and pipe made from ceramics.



SPIRAL-WOUND GASKETS and gaskets made from asbestos and glass cloth impregnated with TEFLON resins are used in high-pressure installations such as pipe joints, reaction kettles, steam couplings, pump bodies, and pressure tanks.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 147, Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec

Please send me more information on the Du Pont engineering materials checked: ☐ ZYTEL; ☐ TEFLON; ☐ LUCITE. I am interested in evaluating these materials for:

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SEND FOR INFORMATION

For additional property and application data on LUCITE® acrylic resin, TEFLON® tetrafluoroethylene resins and ZYTEL® nylon resin, clip and mail this coupon.

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SKF "Triple-Seal" Pillow Blocks, used by an eastern limestone producer in pulverizing tube mills, have saved thousands of dollars since their installation in 1948.

In comparable operating periods, counter-shaft failures dropped from 11 to 2, bearing maintenance costs were cut 49%, production increased 70%, power savings averaged 10% to 20%.

Required to operate in a highly abrasive "snowstorm" of powdered limestone, these triple-sealed units continue to save money for the user. They will do the same for you.

For further information on how these remarkable "Triple-Seal" Pillow Blocks can be applied most effectively to your products, get in touch with your local **SKF** Sales Office. 7738

SKF

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Cylindrical Roller Bearings
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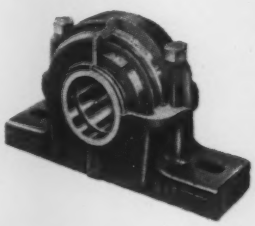

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

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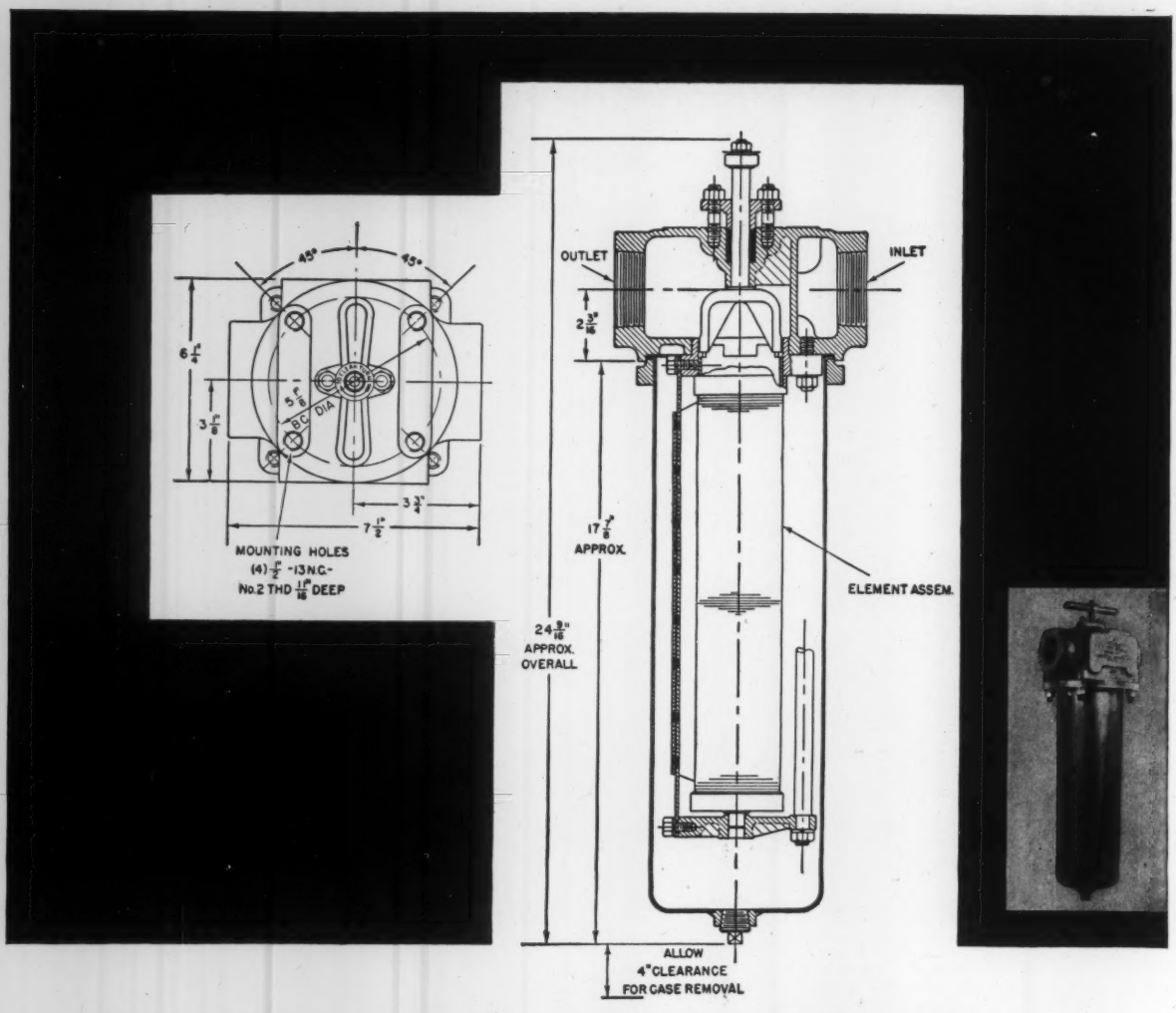

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FOR EXAMPLE... This one standard Purolator filter is exactly right for all these "special" filtration problems:

inks, paints,
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This filter's specifications may recommend it for a problem of yours. If not, you're almost certain to find a standard Purolator filter that does meet your needs—exactly.

SPECIFICATIONS... This is Purolator filter model G-141J with simplex full flow metal element oil strainers. It is designed for primary or first stage filtration and can be installed on pressure or suction side of pump. Recommended for maximum capacities of 40 to 80 GPM, dependent on spacing which varies from .003 to .010. Relief valves set from 10-12 to 50 PSI are incorporated in several models. Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical. Head is made of high tensile cast iron, body of drawn steel. Inlet and outlet connections are 2″, drain plugs are provided. Maximum pressure: 125 PSI; weight: 37 lbs.

Remember, if these specifications don't match your needs, there's probably a filter that does at Purolator. Find out. Send in your problem.

Filtration For Every Known Fluid

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PRODUCTS, INC.

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Circle 467 on page 19

OILITE POWDER METAL COMPONENT DOES "TRIPLE DUTY" IN POWER MOWER

Another cost-saving application of **Amplex Powder Metallurgy**

How to make a self-propelled rotary mower more compact and still permit the rotary blade to operate while the mower idled—*without increasing costs!* That was the problem company engineers tackled. One way was to combine three components—over-running clutch, oil pump piston cam, differential—into one. They experimented widely with designs and materials. Result: an OILITE powdered bronze worm gear with one side of the hub a cam operating the oil pump, the other side a wheel drive ratchet. (The other half of the ratchet—fixed to the drive shaft— OILITE powdered iron.) The design achieved the desired compactness and idling characteristics. OILITE powder metallurgy achieved a *major reduction* in cost, an *increase* in serviceability.

Do you have a design problem? Maybe Amplex has the answer. Write for detailed information about Amplex powder metal components—OILITE Bearings, Parts, Filters. Or call your nearest engineering representative listed in the yellow pages under "Bearings—OILITE."

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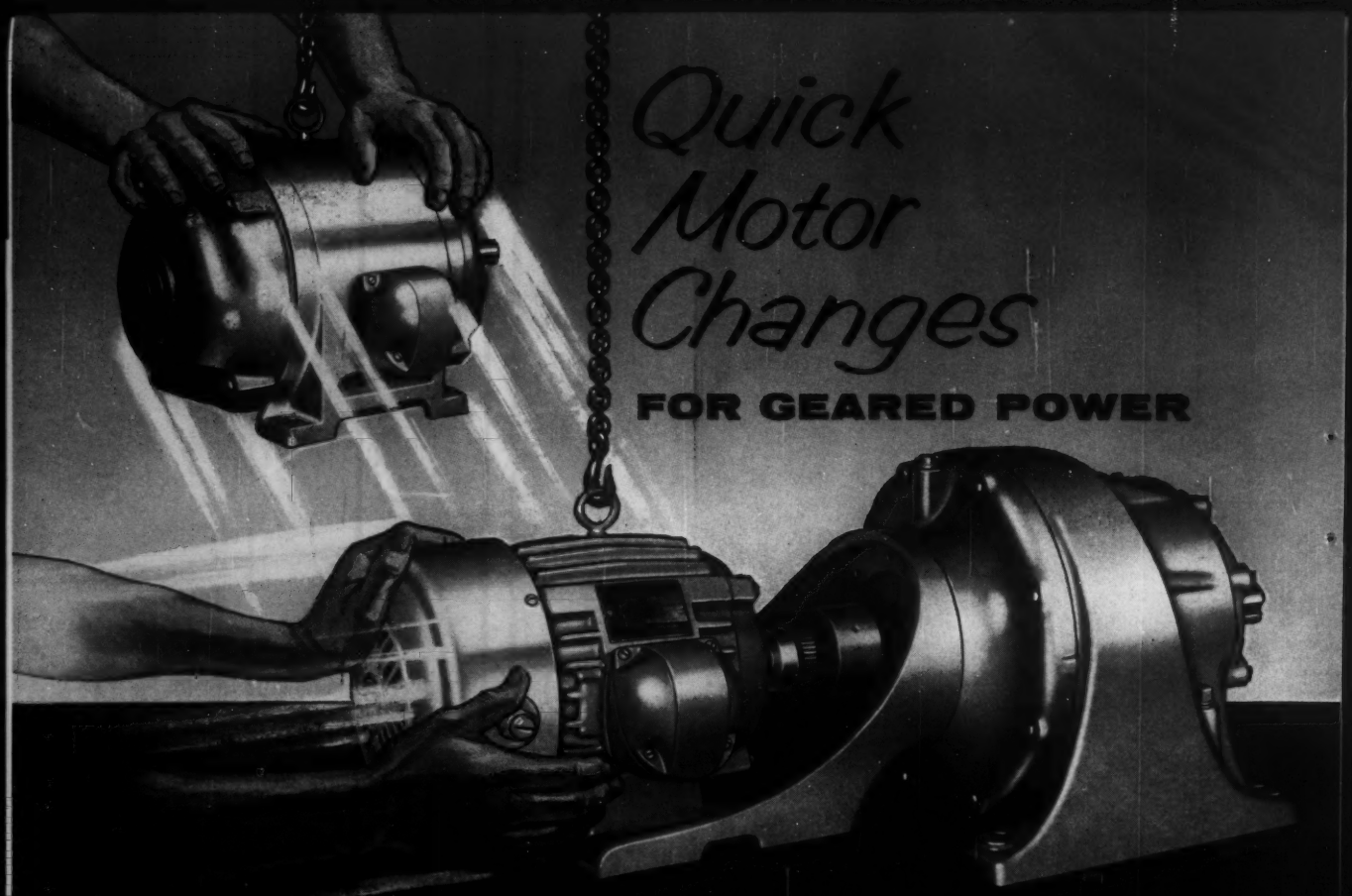


Quick Motor Changes

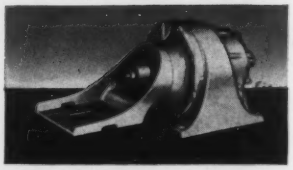
FOR GEARED POWER

New U.S. MOTOMOUNT SYNCROGEAR

Designed to meet J.I.C. Specifications

In one compact power package a high-speed NEMA foot-mounted motor and a low-speed, double reduction gear transmission. Motor change in minutes! And with U. S. Motomount Syncrogear, the change is not limited to the type motor being replaced! If *you* carry a spare motor inventory, here is real flexibility and quick-change. U. S. Uniclosed, Totally-Enclosed, or Explosion-Proof motors of the same NEMA dimensions and ratings may be used to meet changing requirements. Available in h.p. ratings 1 to 30. U. S. Motomount Syncrogear has solid shank ever-tight pinion, friction-free oil seal, thru-hardened gears—many advanced features for longest life.

MOUNTS LIKE AN INTEGRAL UNIT, FOR INHERENT ALIGNMENT... Both units of the U. S. Motomount Syncrogear have rugged, pyramidal base construction—made-to-match pyramids to hold motor and mount aligned for life—factory alignment PLUS centralized responsibility for manufacture of both components.



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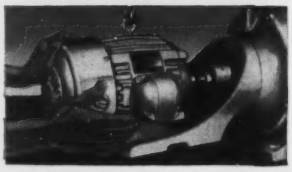

TAKES THE NEW RE-RATED NEMA MOTORS... U. S. Motomount Syncrogear takes the re-rated NEMA motors in the new sizes. The wide range thus acceptable enables you to reduce spare motor inventory!

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U.S. Electrical MOTORS

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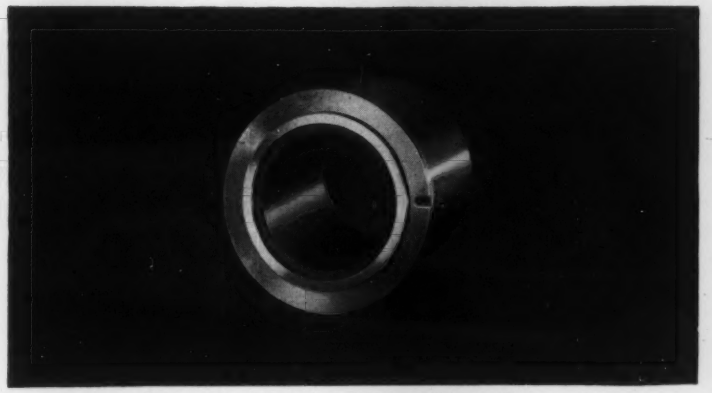
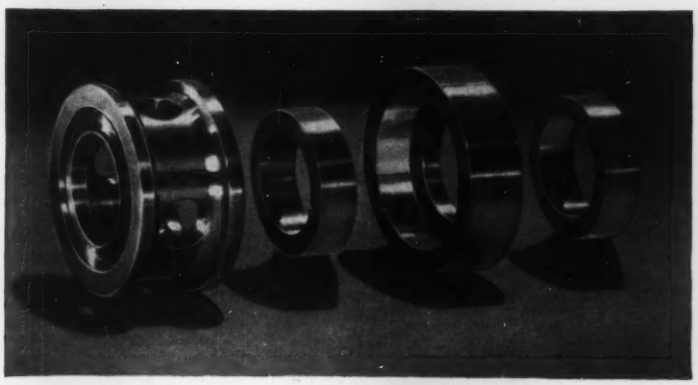


SINGLE BUSHING TYPE Floating Ring Seal

Seal Any Medium—Even Corrosive Media . . . with Koppers Floating Ring Seal

MULTIPLE RING TYPE Floating Ring Seal (assembled)



FLOATING RING SEAL Basic Elements: Lantern Ring, Floating Ring, and Spacer Diaphragm. As sealing needs dictate, floating rings and spacer diaphragms are added. Seals are carbon, plastics, ceramics or steel, as applications require.

The Only "No Maintenance" Seal for Rotating, Oscillating and Reciprocating Motion

Koppers' precise, efficient Floating Ring Seal assures long seal life, low leakage, reduced wear, less power consumption, and decreased operating costs.

It seals at high temperatures and at pressures up to, and for some conditions even above, 2000 psi. Inspection has shown that after 10,000 hours of operation, ring and spindle wear can be negligible. For water at 500° F. and 1200 psig with a $\frac{5}{8}$" spindle, leakage is only one to two pounds per hour. Frictional power requirements are virtually zero, and Koppers' design reduces radial frictional restraint. Sealing members adapt to changes in the shaft's position.

Applicable to valve spindles, pumps, atomic reactor spindles and many other similar installations, Koppers Floating Ring Seal gives efficient, low-cost service for the sealing of all types of fluids under widely varying conditions of temperature and pressure.

For additional information, write to: KOPPERS COMPANY, INC., Piston Ring and Seal Department, 2307 Hamburg Street, Baltimore 3, Maryland.

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Engineered Products sold with *Service*

Circle 470 on page 19

ENGINEERING BULLETIN
ON MICRO-BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: **DYNAMIC AND STATIC LOAD RATINGS**

DYNAMIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions which the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within the normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e.,

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^3$$

The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges the rating life for any load *is a constant number of revolutions*, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L = rating life in millions of revolutions
where, C = basic load rating in pounds
P = applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with 12 pounds, P, a straightedge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

DEFINITION OF EQUIVALENT LOAD

Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the *actual* conditions of load and rotation.

FORMULA FOR EQUIVALENT LOAD

For conventional bearing types other than those with filling notches, the equivalent radial load is given by the maximum of the two values:

a) $P_r = VF_r$ — X is a radial factor
b) $P_r = XVF_r + YF_a$ — Y is a thrust factor
where, V is a rotation factor — F_r is the radial load — F_a is the thrust load

The factor e represents the ratio of $\frac{F_a}{VF_r}$ for which the two equations are equal. If the ratio of loads is such that $\frac{F_a}{VF_r} \leqq e$ then formula (a) is used: if $\frac{F_a}{VF_r} > e$ then formula (b) is used.

For inner ring rotation V = 1.0 in all cases; for outer ring rotation V = 1.2 in all cases except for self-aligning bearings, where V = 1.0. In most calculations involving MICRO bearings, the following values are sufficiently accurate: X = 0.30, Y = 1.04, and e = 0.67. In the case of self-aligning bearings, however, X = 0.40 and Y = 7.6.

In practice, the angular contact type of bearing should not be subjected to a predominantly radial load unless opposed by another bearing.

When a bearing is loaded and at rest the dynamic life formula $\left[L_N = \left(\frac{C}{P}\right)^3\right]$ cannot be used because when $L_N = 0$ then P = ∞. Obviously there is a limit to the Static load which the bearing can carry, this limit being determined by permanent deformations which develop in the load carrying surfaces. Such deformations appear even under very light loads and increase gradually with increasing load, with no sharply defined limit beyond which they begin. The static load limit is dependent on the permissible magnitude of deformation, consistent with requirements of quietness and freedom from vibration. Experience indicates that a permanent deformation in the raceway of less than 0.0001 times the diameter of the rolling elements ordinarily has no objectionable influence on the functioning of the bearing.

In order to obtain an expression for the load carrying capacity at rest, and a numerical value that can be used as a reference, the pure radial load which corresponds to this negligible magnitude of permanent deformation has been selected as the basic static load rating and given the designation C_o.

If the load is much higher than C_o when the bearing is not rotating, minute depressions are formed in the raceways, causing the bearing to be noisy and to vibrate when operating at high speed, even though the bearing friction is not noticeably increased or the bearing otherwise injured. Depending on the requirements in this respect, the static load may occasionally be allowed to exceed the C_o value.

If a load considerably higher than C_o acts only while the bearing rotates, the permanent deformations that occur will be evenly distributed in the raceways and cause no serious impairment until the deformations become relatively large. However, under such a heavy load, the fatigue life will be comparatively short in terms of the number of revolutions. Static load rating values for all MICRO bearings are presented in our catalog-data book.

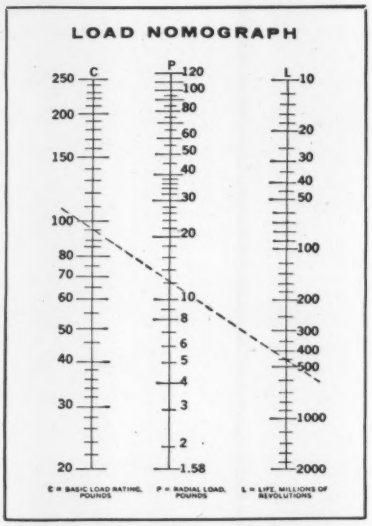

FIG. 1. *Typical cut-away views of instrument-type retainer ball bearings. Complete tabular data on "C" factors and static load ratings are contained in the MICRO Bearings Catalog.*

DESIGN HANDBOOK OFFERED *FREE*

You'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

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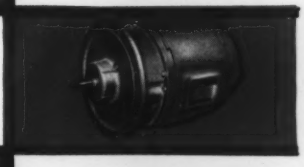
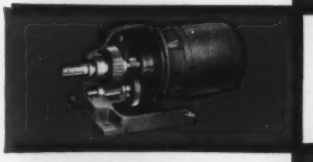
NOW! Speed reduction with space reduction

UTMOST COMPACTNESS is provided by flanged connection of motor to gear drive.

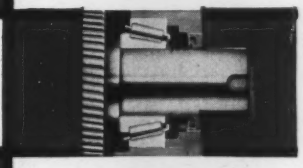
STANDARDIZED FLANGE (one size per motor) permits use of more universally applicable motor.

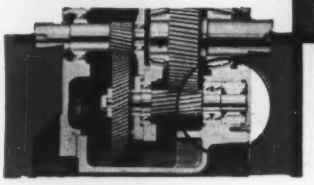




BUILT-IN ALIGNMENT is provided through use of the rabbet-fit NEMA motor.

EFFECTIVE SEALS at all shaft openings keep oil in and prevent dirt from entering housing.





INTEGRAL BACKSTOP to prevent reverse rotation. Can be installed at any time without additional parts or modifications.

LINK-BELT GEARMOTORS maintain positive alignment with flange-mounted NEMA motors

Here's space-saving speed reduction that's made-to-order for tight drive locations. First, because the speed reducer itself is extremely compact, thanks to Link-Belt's advanced gearing methods. Second, the motor is flange-mounted, with no need for coupling devices.

In response to the tremendous demand for these new Gearmotors, Link-Belt can now offer delivery from stock for sizes up to 30 hp, speeds from 280 down to 6 rpm. For details, contact your Link-Belt office.

Ask for new 28-page Book 2447—offering details of design highlights plus complete engineering data.

LINK-BELT

ENCLOSED DRIVES

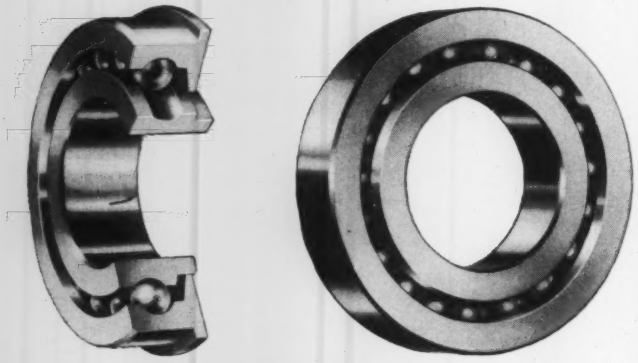
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,317-A

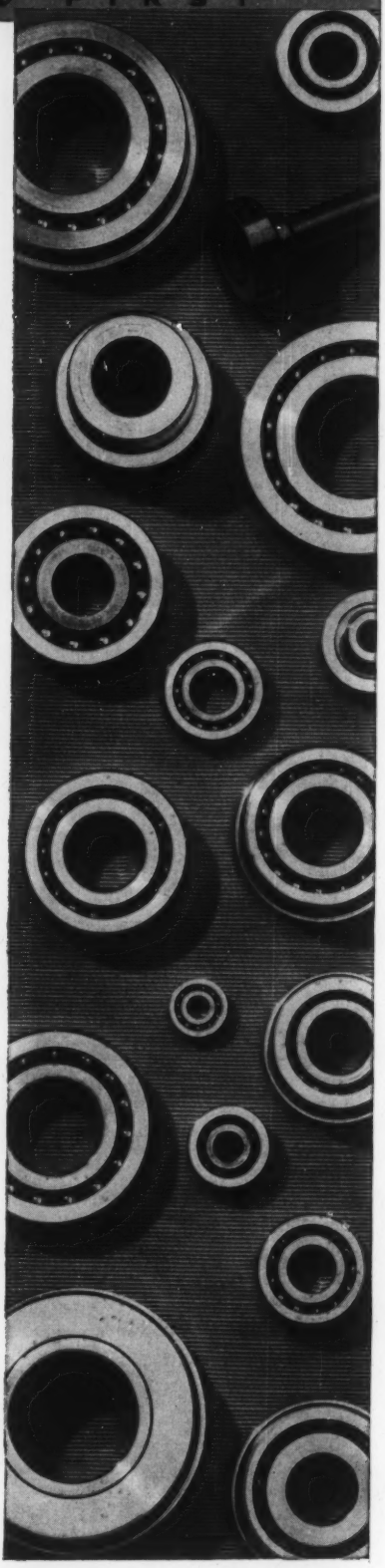
Circle 472 on page 19

ANOTHER HEIM *Unibal* FIRST

HEIM INTRODUCES THE NEWEST IDEA IN BALL BEARINGS

without insertion grooves or inserts





A most unusual, NEW concept in ball bearing design . . .

Here is a commercial ball bearing with solid, unbroken machined inner and outer raceways, yet with a full complement of balls.

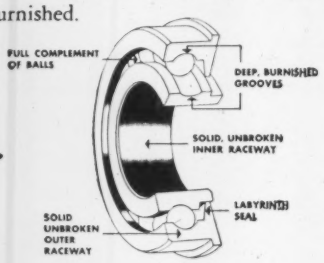
It has deep, burnished ball grooves that are deep carburized and hardened. The revolutionary and radically new method of manufacture permits assembly of these ball bearings in a way that borders on the mysterious and challenges the imagination.

Radial and axial load capacities are increased because of the raceway construction, resulting in longer bearing life.

Unibal Ball Bearings can be furnished in single row, double row and flanged types; to close tolerances on bore and outside diameter; and with controlled radial and axial play.

Close, integral labyrinth seals on one or both sides are another unusual feature, where sealed type bearings are required. Extremely narrow widths and small diameters can be furnished.

NOTE THIS CONSTRUCTION . . .



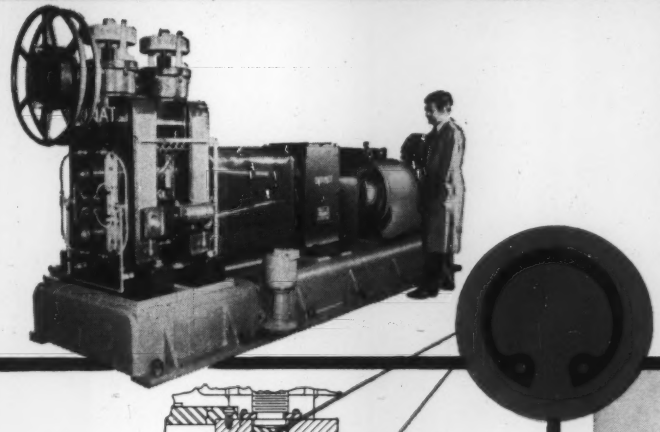
Special circular with load ratings and dimensions on the new Unibal Ball Bearings is available.

HEIM also makes the Unibal Spherical Bearing Rod End. Send for complete catalog of all Heim bearings. Write direct or see your local bearing distributor.

THE HEIM COMPANY / Fairfield, Connecticut

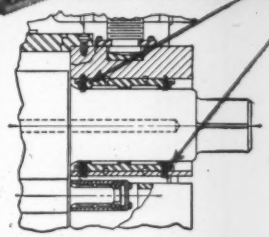
Circle 473 on page 19

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

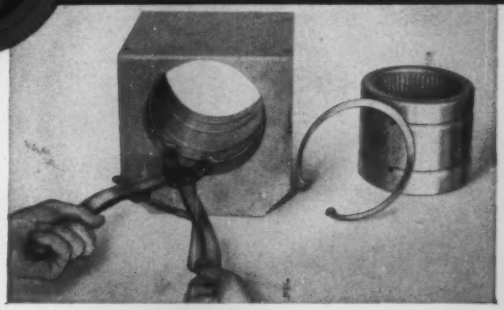


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes...solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts...eliminate costly threading, other machining operations.



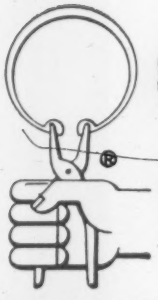
Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!



WALDES TRUARC® RETAINING RINGS

©1956 Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
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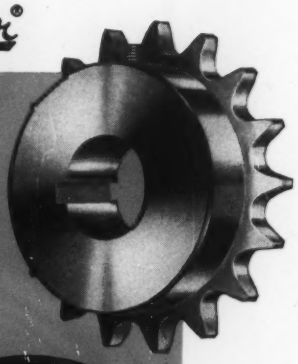
MD079

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

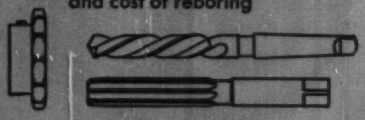
Here's how YOU SAVE with BOSTON Gear®

BORED-TO-SIZE SPROCKETS

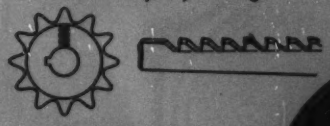
complete with keyway and set screw... ready to install



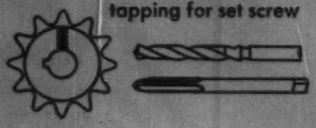
YOU SAVE time and cost of reboring



YOU SAVE time and cost of keyway cutting

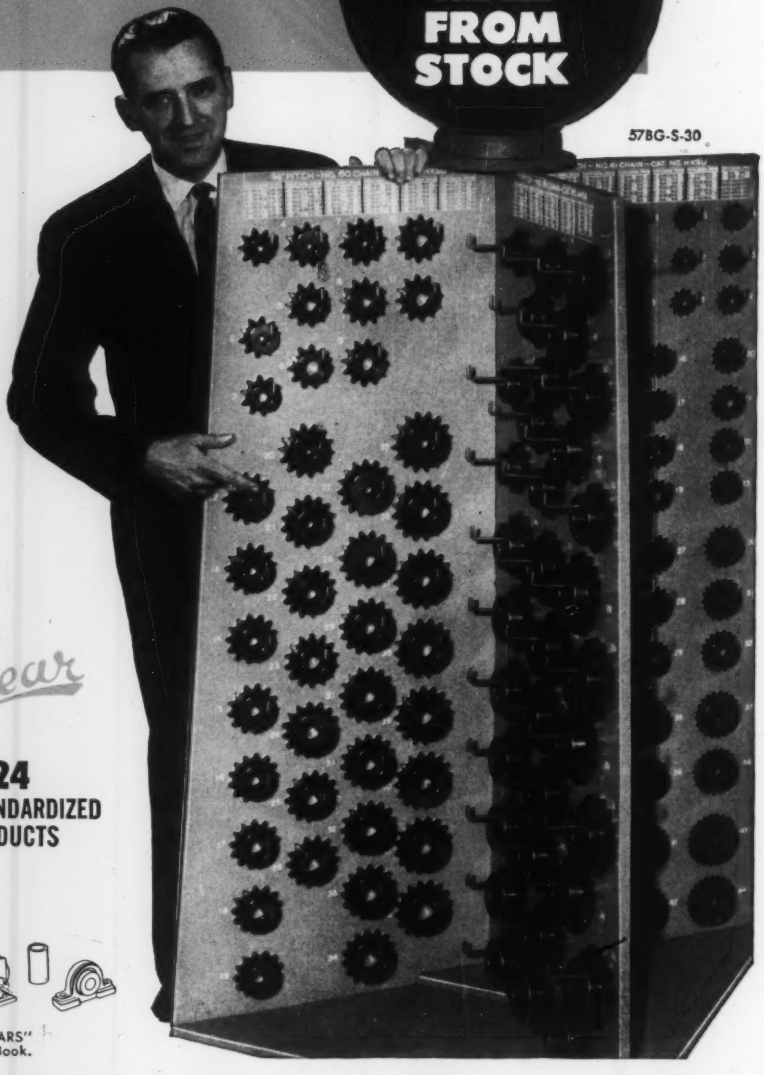


YOU SAVE time and cost of drilling and tapping for set screw



YOU SAVE delay and cost of downtime in emergencies

76 PINION SIZES WITH **321** BORE SIZES **FROM STOCK**



Your Boston Gear Distributor can deliver promptly any size and bore you need from the full selection of 321 different pinions on his BORED-TO-SIZE SPROCKET stock rack.

Why "do-it-yourself" . . . at double the cost? Select the sprocket you need FROM STOCK, and get Boston Gear precision, finish, and performance that assures longer service life for both sprocket and chain. See Catalog No. 56 for complete listings — and other Boston Gear Sprockets to meet any drive need. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

CALL YOUR

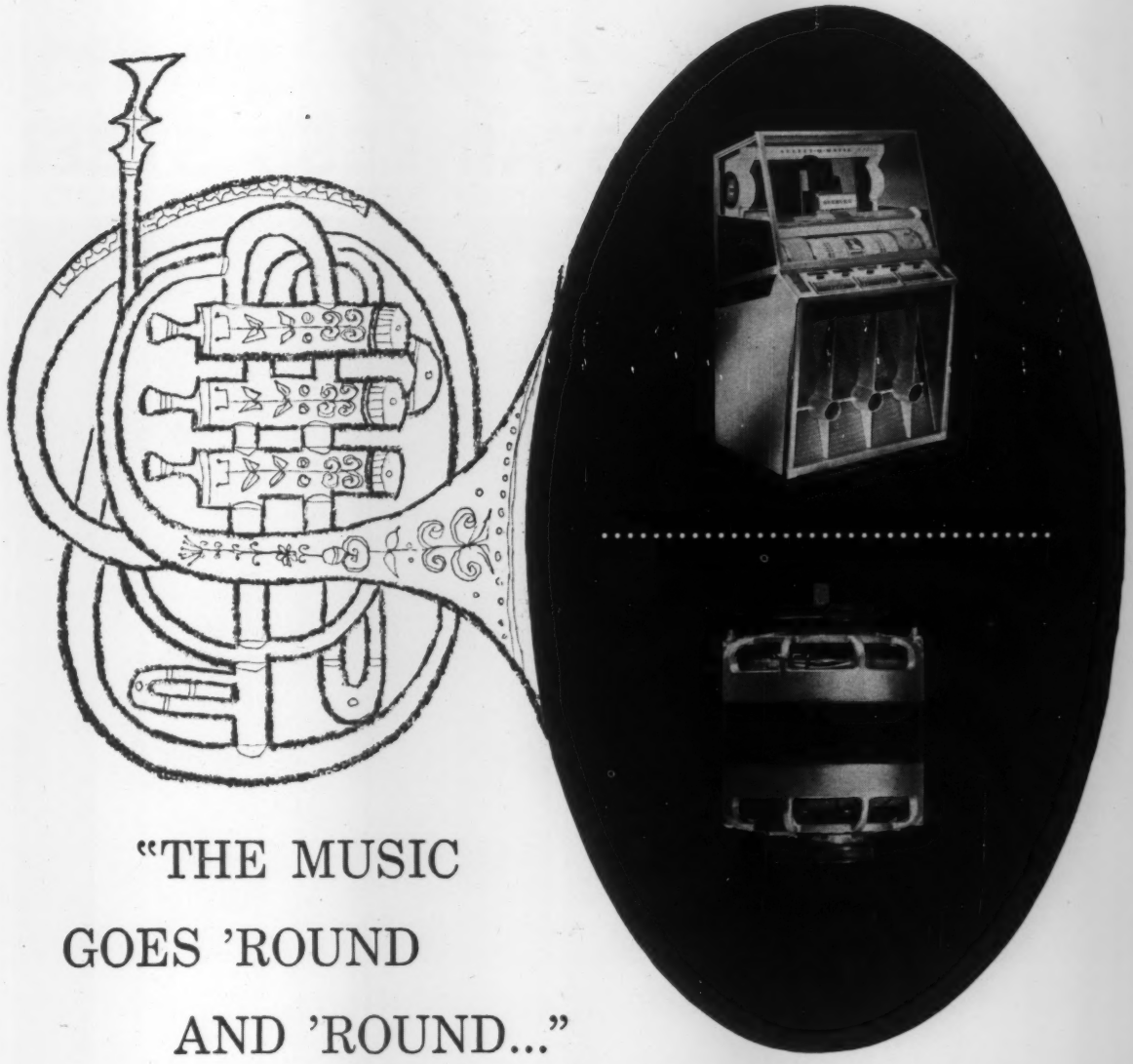
BOSTON Gear DISTRIBUTOR

FOR DELIVERY OFF-THE-SHELF AT FACTORY PRICES

STOCK GEARS SPROCKETS and CHAIN SPEED REDUCERS BEARINGS • COUPLINGS

7124 STANDARDIZED PRODUCTS

For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.



"THE MUSIC GOES 'ROUND AND 'ROUND..."

ON 34-FRAME MOTORS BY WESTINGHOUSE

LET 'EM "POWER-UP" YOUR PROFITS TOO!

Whenever you're "out on the town" and hear the music goin' round and round, it's a pretty good bet you're listening to a Seeburg machine. For Seeburg is America's No. 1 manufacturer of commercial phonographs . . . all powered by 34-frame motors by Westinghouse.

The Westinghouse 34-frame induction motor is designed specifically for business machines—electric typewriters, movie projectors, "jukeboxes", tape recorders, adding machines and a wide range of office equipment. The 34-frame offers outstanding power-to-weight ratio, no radio or TV interference, light weight, quiet operation and amazing dependability. *And* the 34-frame is versatile—it can be tailored to your *specific* requirements. Just look at these features . . .

Housing—Precision die-cast aluminum brackets assembled to machined fits for sturdy construction and light weight.

Bearings—Self-aligning bronze bearings for economy, less maintenance, and long, *quiet* operation. J-03037

Mounting—Supplied with resilient mounting rings for assembly into your base or with complete base. Motors can be mounted in any position.

Whatever your particular requirements, Westinghouse engineers will help you select exactly the right motor. Interested? Just fill out the coupon below for additional information . . .

YOU CAN BE SURE... IF IT'S Westinghouse

Small Motor Division • Lima, Ohio

Westinghouse Electric Corporation
Small Motor Division, P. O. Box 566
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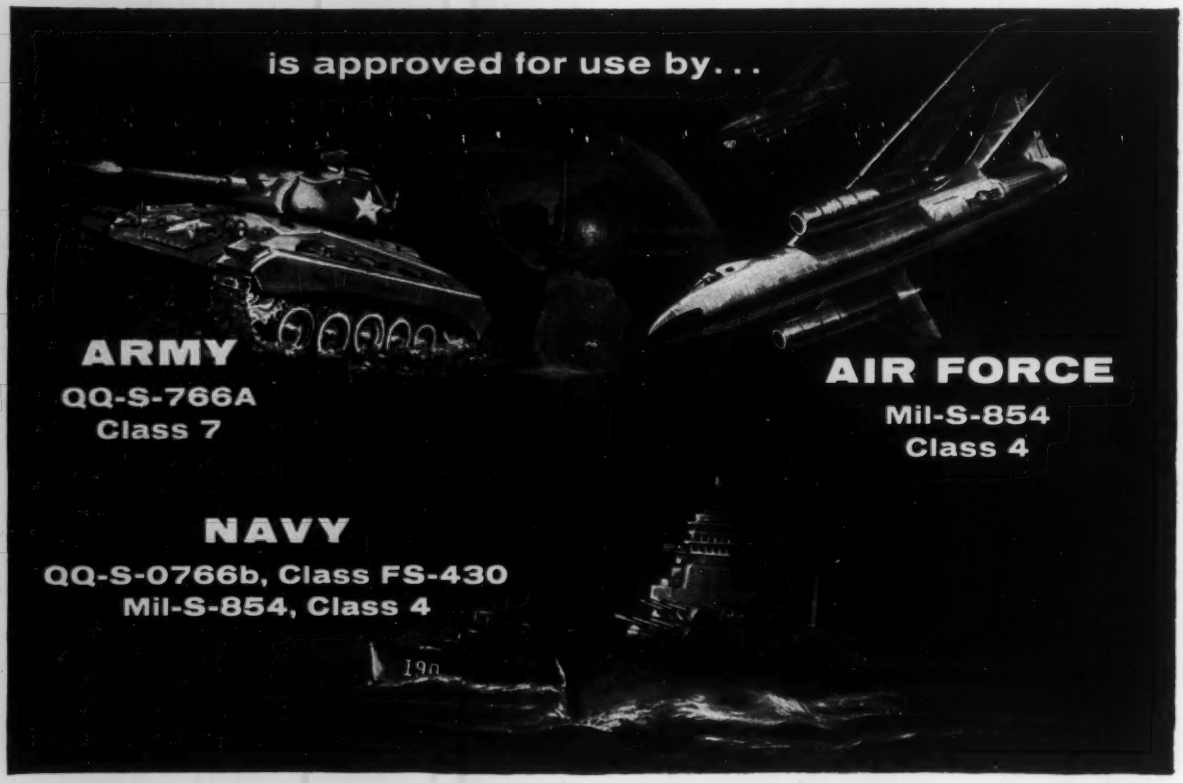
MicroRold® 430

the general utility STAINLESS STEEL



Since 430 meets military specifications, why not investigate this grade for your product

This straight chromium stainless grade possesses desirable qualities of beauty, corrosion resistance, strength, long life and low maintenance that are also of value in many civilian applications. More than 50% of all stainless applications could satisfactorily employ 430 stainless as an economical and practical material. Type 430 stainless costs 10¾ cents per pound less than the 18-8 grade. Some of our customers are already saving more than $215 per ton using our MicroRold 430 stainless sheet. Why not investigate the possibilities of this general utility 430 stainless.

Send today for your copy of our 24-page booklet, "MicroRold 430 Stainless Steel Handbook."

***MicroRold* 430 sheets** are available up to 48″ wide as thin as .010″, and up to 36″ wide as thin as .005″ in commercial finishes and tempers.

Washington Steel *Corporation*

7-E Woodland Avenue, Washington, Pa.

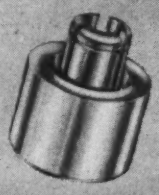
Circle 477 on page 19

HOW MANY WAYS CAN *Special Purpose Fasteners* CUT COSTS FOR YOU?

How many of your products employ laborious, old-fashioned fastening methods where simple fasteners could do the job and cut costs, too? How many parts and sub-assemblies can be adapted to include a self-fastening feature? How many future products could be improved by advance planning for fastener efficiency?

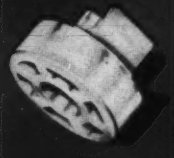
United-Carr's engineering staff offers you a wealth of experience in the design of special-purpose fasteners and self-fastening devices. Large-scale manufacturing facilities (including in-plant plastics molding equipment) ensure economical, *volume* production and prompt deliveries. United-Carr field representatives are ready to call on you at *your* request.

POLYETHYLENE MOUNTING FOOT



No mar, no scratch glide for use on TV receivers, record changers, small appliances, etc. Assembles into round hole in wood or metal cabinets.

NYLON SNAP-IN NUT



Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

QUICKEY FASTENER

Eliminates need for welding or swaging studs to sheet metal stampings, facilitates nesting, eliminates damage in transit because Quickey snaps in before final assembly.

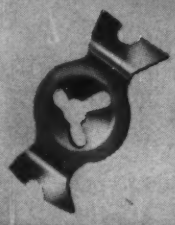
THREAD CUTTING FASTENER

Re-usable, self-locking, vibration-proof fastener cuts clean, deep threads on unthreaded chrome-plated studs. Available for 1/8", 5/32" and 1/4" studs.

PLUG BUTTONS

Snap into 1/8" to 3" dia. holes. Can be embossed with ornamental or functional designs . . . various finishes, shapes and sizes.

FISHTAIL RATCHET PLATE



Holds on smooth, die-cast metal or plastic studs to anchor name plates, trade marks etc. on appliances, automobiles, electronic apparatus, etc.

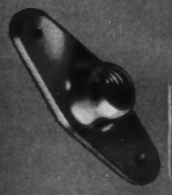
TRIMOUNT STUDS

Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration proof attachment. Permanent or removable. Many shapes and sizes.

V-LOCK TEENUT

Re-usable, self-locking, one-piece, all-metal nut has high tensile strength, is unaffected by heat or oils. In various shapes, sizes and metals.

SOL-A-NUT



Self-locking, rustless, heat resistant. Sturdy, one-piece stainless steel construction prevents corrosion if nicked or scratched.

DURABLE DOT FASTENER

Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

CARR FASTENER COMPANY

Division of United-Carr Fastener Corp., Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

Circle 478 on page 19

NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

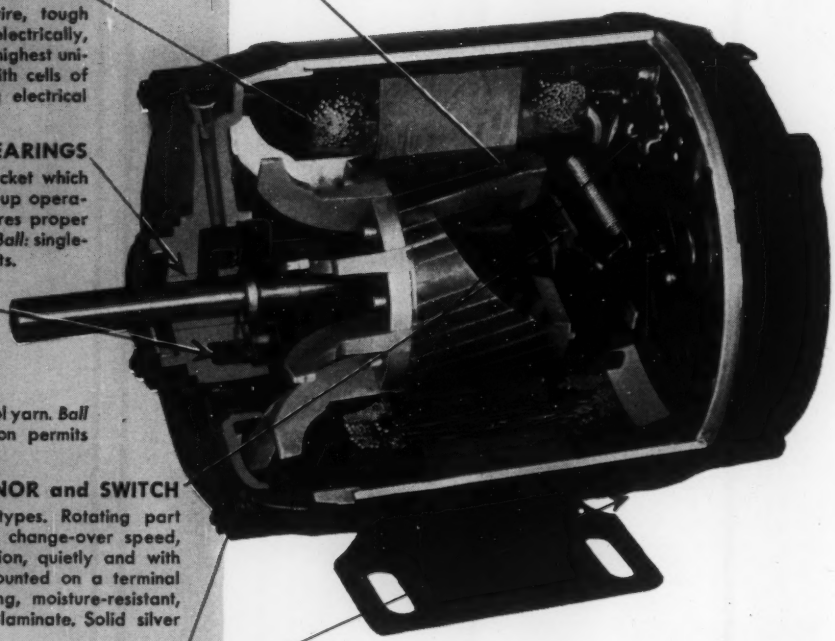
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



Century Industrial Quality means *design* that does not compromise dependability to gain slight cost advantages... sturdy construction provides the stamina which assures continuous operation. 48-Frame Motors now available from 1/20 to 1/3 HP... Performance-Rated to your needs... with weight savings up to one-third!

Test one of these motors for yourself. Call or write your nearby Century District Sales Office or Authorized Distributor. Send for new bulletin 1-1P1.

Performance-Rated© MOTORS
1/20 to 400 HP

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

64

Circle 479 on page 19

WAITING FOR A CHANGE

Development of aircraft and aero engine design is a pattern of never ending changes and modifications. Improving engines and airframes demands more strength in more and better parts. Example: There are about 1,300 machined parts in the F-100A. In the F-100D, improvements have added 500 more. Higher power and speeds in the same size airframe call for improved elevated temperature performance in alloys for structures, forgings and fasteners.

The big problems have been the forgeability and machinability of the tough alloys used in the intermediate elevated temperature applications. But they're being licked. Carpenter is now producing uniform elevated temperature alloys of very high quality which consistently meet tough aircraft specifications. Their quality and cleanness also allow tightened forging tolerances, improve machinability and cold forming properties. Result: More accurate forgings with better finishes . . . fewer rejects . . . faster production.

Complete information on application, fabrication and engineering properties of these alloys is summarized in our new booklet, "Carpenter Alloys for Elevated Temperature Service". For your copy, drop us a line on your Company letterhead. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

Circle 480 on page 19

(Advertisement)

New trends and developments in designing electrical products...

- First radially heat-treated magnets ever mass-produced
- G-E thermistor makes new temperature controls more sensitive

G-E Magnet Engineers turn idea into reality

The physicist at Roanwell Corp., Brooklyn, New York, had the idea – but it took a revolutionary development in magnet manufacture to make it come true.

Roanwell was working on a new receiver for military headsets sensitive enough to distinguish sounds clearly, even under combat conditions.

A new, dynamic receiver design solved the sensitivity problem. But then the weight and height of the unit had to be reduced to make it less bulky in the aviator's helmet.

Original specifications called for an assembly of several magnets which was smaller than the plug-type magnet normally used. But the Roanwell physicist's idea was to use a *single* radially heat-treated Alnico 5 magnet to reduce the size still further, and eliminate extra fabrication steps.

No one had ever mass-produced a radially heat-treated magnet like this before (Fig. 1). And no one knew if it could be done. So Magnet Engineers from General Electric were called in to try.

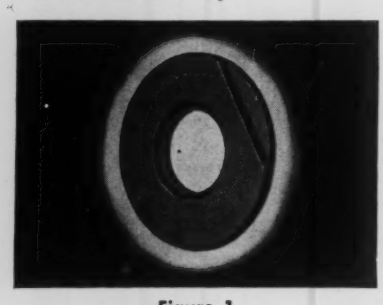


Figure 1

They solved the problem all right. But here's what they had to go through to do it:

First, they came up with special directionalizing equipment to orient the magnetic domains so the magnet could be magnetized radially.

Next, with engineers in G.E.'s unique Quality Standards Laboratory, they worked out the processing technology for mass production.

This meant starting from scratch to determine the initial heating temperature, rate of coiling, best field shape. It meant calculating axes of the directionalizing coil, computing proper aging time and temperature. And finally, it meant thorough testing and careful control of production.

The result: Roanwell is now using the first commercially produced radially heat-treated magnets (Fig. 2). The magnet produces the same flux density, but it requires less height (in fact, about half the height of a plug magnet).

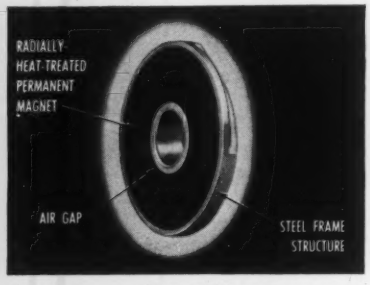


Figure 2

Because a single magnet is used, the unit is stronger, more reliable . . . and has the needed sensitivity. Equally important, the magnet can be machined accurately. This is critical because the circular air gap for the vibrating coil (see Fig. 2) is only a few thousandths wide, and magnet tolerances must be held as tightly as possible.

For Roanwell, G-E Magnet Engineers came up with this new method for mass-producing radially heat-treated magnets. For other manufacturers, they have handled jobs ranging from the design of complete magnetic circuits to development of new magnetizing and testing procedures.

Whatever the problem, G-E Magnet Engineers have the experience, skills, and the facilities behind them to solve it.

To get their expert design assistance, or your copy of the new G-E Magnet Design Manual, all you have to do is write: *Magnetic Materials Section, General Electric Company, 7814 N. Neff Road, Edmore, Mich.*

G-E thermistor gives new temperature control sensitivity to 0.075° F.

Furnace heat maintained at given levels, and alarms sounded when temperatures exceed specified limits – both can be controlled by a new device called the "Simplytrol."

The Simplytrol is made by Assembly Products, Inc., Chesterland, Ohio. It responds to changes as small as 0.075° F. because it uses a G-E thermistor as the sensing device.

The thermistor is one leg of a bridge in circuit with a D'Arsonval meter relay. (Fig. 3).

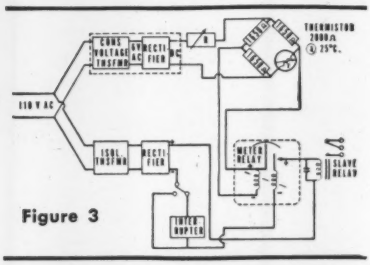


Figure 3

Because the thermistor has a large *negative* temperature coefficient of resistance, even minute changes unbalance the bridge to let the current actuate the relay.

The thermistor is more sensitive than other types of sensing elements. And in the Simplytrol, it can be wired up to 200 feet from the control without affecting accuracy.

In these and similar devices, the thermistor senses changes in ambient temperature. However, when it is heated by the current of the circuit, a whole new range of applications is opened: voltage regulators, time delays, sequence switching devices.

If you have problems in these application areas, experiment in your plant with G-E Thermistor Kits – they're only $12.50 each. To find out which is best suited to your needs, write: *Magnetic Materials Section, General Electric Company, 7814 N. Neff Road, Edmore, Michigan.*

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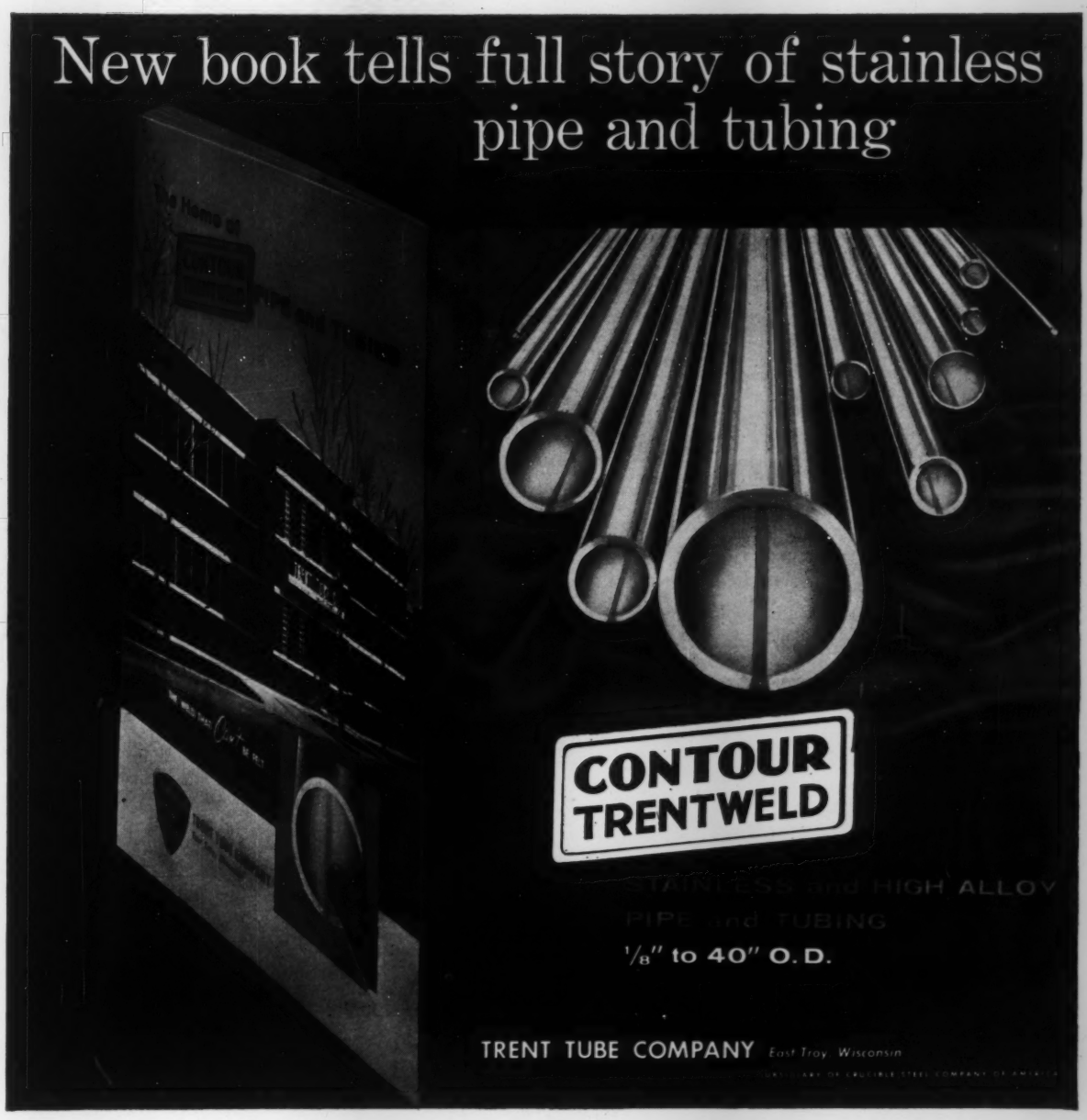
Circle 481 on page 19

New book tells full story of stainless pipe and tubing



If you use stainless or high alloy pipe or tubing, this new illustrated handbook was written for you. It's 58 pages big – packed with informative data that you'll refer to again and again.

The table of contents is too long to list here, but it includes, for example, analysis and conversion tables, corrosion characteristics, weights, alloy properties, bending, joining and installation hints.

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Circle 482 on page 19

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Special attention to insulation—Louis Allis sponsors continuous research into new insulating materials. One example: Louis Allis engineers were first to combine Gilsonite with phenolics and alkyds. The result is a varnish with the highest degree of moisture, acid, and alkali resistance — extra-long life for all motor uses whatever your design problem.

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The complete story is in our Bulletin 1700. May we send it to you? Contact your nearby Louis Allis District Office or write The Louis Allis Company, 427 East Stewart Street, Milwaukee 1, Wisconsin.

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LA-110

Circle 483 on page 19

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Circle 484 on page 19

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The Bellows Co.

AKRON 9, OHIO

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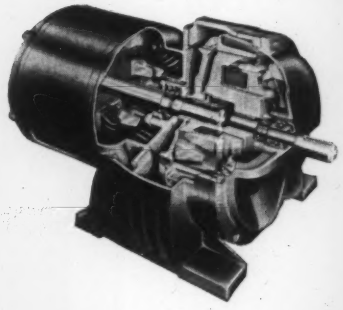

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Dynamatic Ajusto-Spede® Drives supply infinitely adjustable speed from an AC power source—with low power losses and minimum maintenance. These air-cooled, stationary field, eddy-current couplings, integrally mounted with standard D-flange AC induction motors, provide a complete package-drive in sizes from 3 HP to 75 HP. Units of the same design and capacities are also available without motors.

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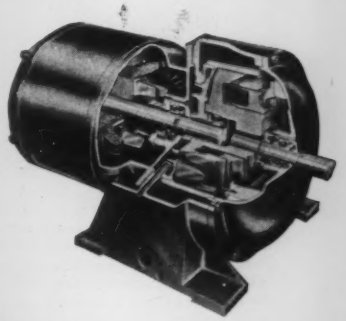
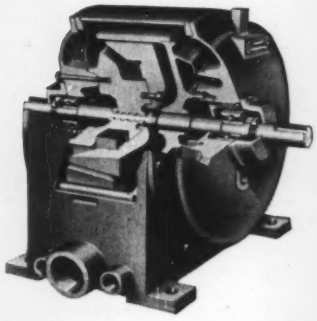
These Dynamatic liquid-cooled, adjustable speed, Eddy-Current Couplings, integrally mounted with standard D-flange AC induction motors provide a compact self-contained drive in sizes from 3 HP to 75 HP. Motor types available are drip proof, totally enclosed fan cooled, and explosion proof. The coupling is completely enclosed. Separately mounted couplings are also available in capacities from 3 to 2500 HP and larger.





Eddy-Current Brakes

Dynamatic Eddy-Current Brakes are available in a wide range of torque capacities and operating speeds. Features include smooth, frictionless, shock-free operation with no rotating electrical components or contacts. Liquid-cooled types, as illustrated, provide loading requirements from 40 HP to 10,000 HP. Air-cooled units are available in sizes up to 50 HP.

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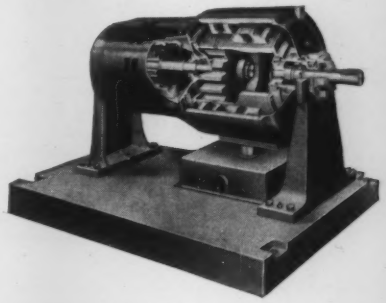

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Circle 487 on page 19

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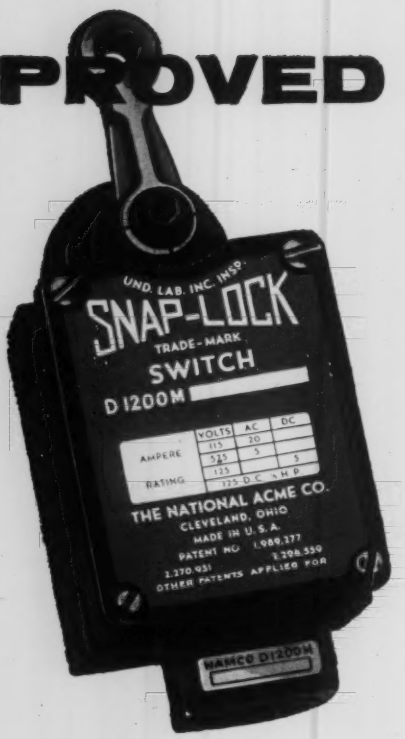

NATIONAL ACME
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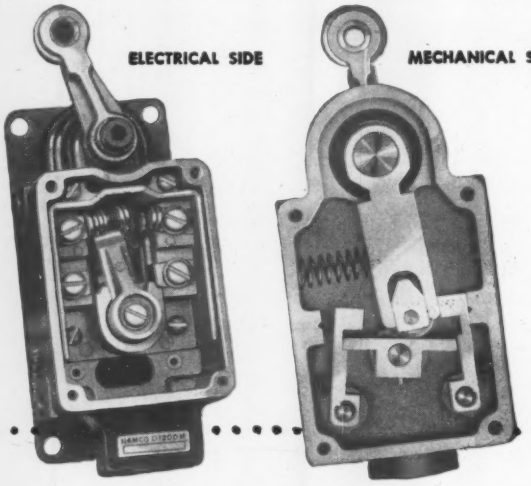
As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service, far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil-tight.



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SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

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a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have ¾" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
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Circle 488 on page 19

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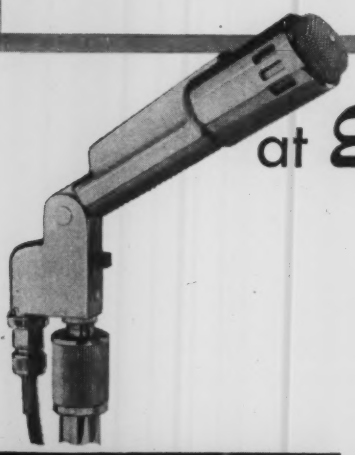
THOMSON INDUSTRIES, Inc.
Dept. C-5, Manhasset, New York

Circle 489 on page 19

There's a Good Reason why

ZINC DIE CASTINGS

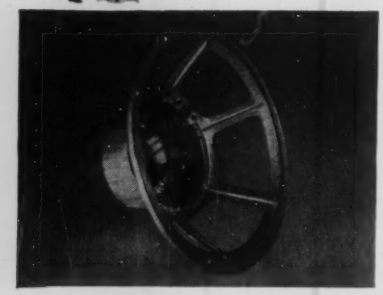
are so widely used



at Electro-Voice®

it's

RIGIDITY



Electro-Voice is outstanding in the design, development and manufacture of high-fidelity speakers and components in the field of sound reproduction. Its choice of ZINC Die Castings for these products was based on extensive research and intelligent utilization of valuable properties inherent in ZINC as a die casting alloy.

Replacing materials formerly used, ZINC Die Castings were found to give greatly increased RIGIDITY— an extremely desirable quality when heavy magnets and magnetic assemblies are used, as in the 15TRXB speaker shown above.

Electro-Voice professional quality microphones such as this 664 Cardioid Dynamic have used ZINC Die Castings for several years. Smooth finish, more efficient design and greater impact strength — as well as RIGIDITY— are the reasons for this choice of material.

Notice the ribbed structure of the speaker frame. Here are thin walls and strength where needed—RIGIDITY from every angle. For the Model 635 microphone, these polished die castings incorporate many of the advantages of ZINC, including labor-saving assembly.

Any die caster can show you other examples of improved products and lowered manufacturing costs gained by using ZINC Die Castings. Have you considered whether the same advantages can be incorporated in your products?

THE NEW JERSEY ZINC COMPANY 160 Front Street, New York 38, N. Y.

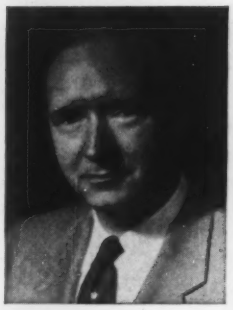
The research was done and the Zamak die casting alloys were developed with

HORSE HEAD SPECIAL (99.99 + % Uniform Quality)

ZINC
FOR DIE CASTING ALLOYS

Circle 490 on page 19

MACHINE DESIGN
July 11, 1957



What's in a Name?

DISCERNING readers will have become aware of a "new look" on our front cover and on this page. Lest they jump to unwarranted conclusions, we hasten to assure design engineers that the appearance change, inaugurated with the May 16 issue, represents neither an artist's whim nor a change in policy.

When MACHINE DESIGN was founded twenty-eight years ago the name connoted a well recognized field. It still does. By usual definition, a machine is simply an assembly of mechanisms which performs a useful function.

As man's implements were mechanized, their traditional names were sometimes prefixed with the word "machine": machine gun, machine tool. Or their function was followed by the word: sewing machine, adding machine, vending machine. Many of these designations persist but others have been replaced by new words: flying machine (airplane), talking machine (phonograph). Some have been abbreviated: calculating machine (calculator), refrigerating machine (refrigerator).

Such expressions as "He was hit by a machine on West Third Street" are still heard, but modern usage tends toward dropping the word "machine" for this and many other products in the category of machines.

Recognizing the trend, we have chosen to emphasize design in our label to denote the function we serve. At the same time we are retaining "machine," *sotto voce,* to help further define our scope in accordance with precise definition.

We hope the modification will help those readers whose products are no longer called machines to feel more at home here. Our policy remains unchanged: to serve the needs of design engineers of all powered products, regardless of name.

Colin Carmichael

EDITOR

Developing Ideas for

Ideas are the building blocks of new-product programs. This article, second of a group on new-product development, describes four ways to collect useful ideas in quantity.

FIRST consideration in development of practical new products is a clear understanding of what is meant by *new*. It is also necessary to know what criteria may be applied to reveal presence or absence or "newness." Generally, new products fall into one of three categories:

First, any idea relating to a *new function* should immediately be classified as a new product. Electrical heating of blankets, wireless synchronization of electric clocks, and the speaker-phone are examples of new functions in familiar consumer products.

Second, any idea relating to an *improved function* represents a potentially valuable new product. Records for 45 and 33⅓-rpm, Merion bluegrass and latex-based paints are examples of improved functions in readily recognizable consumer items.

Third, any idea that contributes to *lowered costs* should be considered. Lowered costs in competitive markets represent innovations just as real as new or improved functions.

The Organized Approach

Successful product development depends largely on willingness to adopt certain attitudes at the outset. Developing a high degree of receptiveness is important. Too often the mistake has been repeated of looking for new products by searching only in a single direction. Some search out new patents—but this is only one source of ideas. The search should not be limited to patents or literature or inventors. What is seen and heard and sensed should be mentally and physically recorded. An organized approach should result in reconstructing new knowledge in different forms in an effort to synthesize something that has not existed before.

Step One—Establish Objectives: In developing new-product concepts, certain parameters should be established to be in keeping with management interests. It is unrealistic to assume that any and all potentially profitable new products will be of interest.

The first step in developing new products should start with a top-level conference attended by executives responsible for over-all company operations. At this conference, long-range interests should be revealed, along with sufficient accompanying background thinking to enable those individuals who are specifically charged with the task of developing new concepts to exercise judgment that parallels top-management thinking.

Management should indicate the limits imposed on the search for new-product concepts. Is the sky the limit or is the search limited to cost-reduction concepts?

Within this range, practical working parameters can be established. Every effort should be made to allow the fullest possible latitude in searching out new ideas, but if any limitations are imposed by top management, these should be known at the outset.

Top management's long-range interests set the ground rules for the search. The fewer the rules, the greater is the chance of success. Complete freedom of operation, however, may suggest that management has not been clear in setting forth its thinking. Trouble may come later when management does clearly delineate its interests.

The greatest contribution management can make at the outset of the search is to pass on any knowledge it has of especially interesting new commercial opportunities. Executives, through their wide range of contacts, may be able to highlight especially promising prospects. Growth prospects generally are the result of the operation of one or more of six major forces operating within the economy:

1. Shifts in population patterns that effect changes

New-Product Programs

By Philip R. Marvin
Manager, Research and Development Div.
American Management Association
New York

in supply, demand and preferences.
2. Defense programming that is responsive to local, political and world-wide influences has a far-reaching effect on growth opportunities.
3. Legislation by federal, state and local bodies may be a regulating factor.
4. Court opinions on issues of a socioeconomic nature reveal directions to follow.
5. Patents allowed by the U. S. Patent Office are of widespread significance in programming.
6. Technological advances in recent years have assumed a position of great importance among external factors influencing product planning.

Step Two—Search, Do Not Screen: One of the ingredients of success in developing new ideas lies in divorcing the searching process from the screening process. In the initial stage, as many new ideas as possible must be accumulated; quantity, rather than quality is the goal. Objective at this point is to avoid rejection of ideas before selection criteria are well established and to avoid rejection by unqualified individuals.

In searching for new-products concepts, product opportunities must be looked for—the need for new products, as well as ideas for new products themselves. The need for a product can often be used to generate new ideas. Consumer demand for color television, for example, sparked a flow of invention oriented toward this achievement. The need for high-temperature materials stimulated inventive efforts in this direction.

Step Three—Set Up a New-Product Panel: The search for new-product concepts should be pursued within the corporation, and equally vigorously on the outside. However, the starting point for sound programming lies within the corporation.

To stimulate the development of new-product concepts inside the corporation, the importance of new ideas must be stressed. A real interest in such ideas should be shown. Generating ideas is not a process that can be turned on quickly. Development of a favorable climate for idea generation within the corporation requires careful planning and takes time. Nonetheless, the rewards are great and the results are well worth the time involved.

To gain acceptance of the fact that new products are of sincere interest, both written and spoken channels of communication within the corporation should be used. Company publications carrying feature articles outlining the value of new ideas to the long-range growth of the corporation are impressive. Reprints of articles from other publications that reveal the importance of new products can help put the point across. Rewards can be used to stimulate a flow of new ideas.

Along with the problem of developing a flow of ideas goes the problem of detecting and collecting them. Collection of ideas is a particularly critical problem, requiring that a favorable climate for the free flow of ideas be maintained. One of the most successful methods of coping with this problem, and a method applicable to corporations of any size, is the establishment of a hand-picked group charged with the specific responsibility of generating and collecting new-product ideas.

The most important qualification for members of this group is demonstrated creative ability. Diverse interests among members of the group is also important. One such group combines a production expert, an artist, an inventor, a designer, an analyst and an engineer, all of whom demonstrated creative capacity before being selected. Rank is a relatively unimportant factor, for the most part, when the individuals selected combine a really high degree of creative ability and genuine professional capacity.

The New-Product Panel—Its Objectives and Functions: It cannot be overemphasized that the objective of the new-product panel is to accumu-

late a maximum number of ideas relating to potential products. In the course of day-to-day business activities, finding and screening new ideas are commonly linked together. To form a clear picture of the scope of activities of the new-product panel, the function of finding ideas must be clearly disassociated from the function of screening.

The new-product panel's only concern lies with the accumulation of the largest possible number of new-product ideas. If it is to operate at top-level effectiveness, it should never concern itself with screening functions. This separation of the screening function from that of developing new ideas is all-important and fundamental to the success of the process.

In achieving its objective, the new-product panel members must pick up any pertinent new ideas they run across; their own creative powers should be productive of others, and they should produce a flow of ideas from every possible source.

Operating both inside the company and on a broad scale outside of the company, the new-product panel's sources can be classified in the general categories of:

1. Bird dogging new ideas
2. Synthesizing ideas
3. Generating new ideas
4. Catalyzing new ideas

The first of these infers that at all times, members of the panel are looking for sources for ideas as well as the ideas themselves. Synthesizing is the process of combining two or more ideas to yield yet more. The chain-reaction thinking process is very productive. Generating new ideas refers to development through the creative powers of the panel members themselves. Catalyzing new ideas is the process of sparking a flow of ideas from individuals possessing latent talent.

First Way—Bird-Dogging for Ideas

To develop perspective at the outset of the search, the panel should scan the business horizon for new ideas. In accomplishing this objective, there are a great many sources that are potentially productive of new ideas and that should be tapped. No single listing of these sources could ever be complete, but a few will suggest others equally valuable.

One way to develop new ideas is to hire someone to do the job. The new-product panel can get outside assistance by hiring the services of firms engaging in survey work. Their individuals should combine training, knowledge, experience and innate capacity with the ability and skill to exercise judgment in this area of business specialization.

Highly competent performance and service may be rendered by those qualified by training, practical industrial experience and specialization to perform these services. Those who employ such services will receive an adequate return on their investment.

When outside assistance is employed, certain

SOURCES FOR IDEAS

1. Venture-capital organizations seeking corporations interested in financing the development of new products.
2. Directors of research in other corporations with new-product ideas available on a royalty basis.
3. Newspapers, trade journals, and magazines revealing new products.
4. Organizations and individuals available to search patent records for ideas that can be developed.
5. Professional societies and business organizations with staff members specializing in segments of business activity.
6. Purchasing agents knowing of special market requirements.
7. Inventors with potentially marketable ideas.
8. Public-utility companies interested in developing commercial opportunities for their services.
9. Manufacturers' representatives familiar with new developments.
10. Government services related to both industrial and military activities.
11. City, county, and state industrial-development commissions charged with industrial growth of specific areas.
12. Patent attorneys representing client inventors of new products.
13. Trade associations interested in specific areas of industrial activity.
14. Advertising agencies creating merchandising programs for products to be farmed out for manufacturing.
15. Commercial bankers directing new-product financing activities.
16. Consulting engineers working on projects in the idea and design stage and looking for a commercial tie-in.
17. Sales representatives alert to market needs and potential new developments.
18. Scientists, engineers and technicians possessing developable ideas.
19. Business acquaintances and personal contacts that are particularly observant of market needs and opportunities for new industrial ventures.

responsibilities must remain with the new product panel:

1. The panel should adequately define the company's interests in new product ideas—scope of interests, limitations inherent to these interests, and associated factors. Effective action by any survey group is premised on an adequate delineation of these parameters of the search.
2. The panel should inform itself of the complete background of each individual who will be charged to the account. Only competent manpower should be used on the job.
3. Panel members should know what rates are charged and should request detailed periodic accounting to insure adequate control.
4. The panel should work closely with the survey team to make full use of their findings.

Sources of New Ideas: A great many potential sources of ideas must be included in the search by panel members. A partial list of such sources is given separately. This list may seem exhaustive—and exhausting to one part-way through the search—but a single really good idea is worth a lot of effort. All of these sources have been found fruitful. Their sequence has no direct bearing on the specialized requirements of any particular search. In general, however, each of the sources listed should be investigated.

▶ Second Way—Synthesizing Ideas

The importance of demonstrated creative ability as a primary qualification for members of the panel has been stressed. Unless the members of the new-product panel possess this ability, a good share of their effectiveness will not be realized. It is a rare occasion when bird dogging new-product ideas that one comes upon an idea that is fully spelled out in useable form. More commonly, leads are encountered that steer thinking in directions that may result in new products. Idea sources prove barren unless explored by imaginative minds.

For example, one engineer, learning of the development of an electrically conducting resin, conceived an idea for its use if the resin could be made transparent. It might then be coated on glass panels and used to keep automobile and aircraft windshields free of ice in winter by passing current through the coating and heating the windshield. In another example, a scientist, reviewing saturable-core reactor development data, recognized that this electro-magnetic device had advanced to the point where it would be possible to couple it to a transistor to create a temperature-sensitive control without any mechanical or moving elements.

Many examples could be cited showing how new-product concepts result from combination, association and evolution of ideas. The efforts of panel members lacking highly developed creative capacities would fall short of the desired goals in utilizing information at their disposal.

▶ Third Way—Generating Ideas

Members of the panel are specifically charged with the responsibility for generating new-product concepts. They are expected not only to search for new ideas, but to utilize all information that comes to their attention to full advantage in generating new concepts. This job calls for acute awareness and sensitiveness that are responsive to the slightest hint or suggestion of a potential new product.

The make-up of the new-product panel will determine its productivity. Management's principal control is exercised by making certain that the right individuals are selected for the panel. Emphasis should be placed on demonstrated creative ability and ability to associate ideas and facts in new relations. These are two of six attributes which have been found to complement each other in the make-up of individuals suited to serve on the new-product panel. The six attributes are:

1. Demonstrated creative capacity.
2. Ability to associate ideas and facts in new relationships.
3. A questioning approach.
4. Acute powers of observation.
5. Capacity for concentration.
6. Broad training and experience.

In using this guide it should be remembered that no two individuals will be alike in the way they combine these attributes.

Demonstrated Creative Capacity: Individuals who have performed creative work have learned, in varying degrees, how to break through emotional, social and analytical barriers to creative thought processes. They have learned consciously or subconsciously the creative process of thought. Such individuals are outstanding candidates.

Ability to Associate Ideas and Facts in New Relationships: The value of an idea is largely a product of its environment. A process for quick freezing a biological specimen for microscopic examination takes on added significance from a dollar viewpoint when thought of in relationship to food processing. The art of investment casting in the jeweler's and dental technician's laboratory assumed even greater importance to the precision-parts manufacturer. This ability to transplant ideas into a new environment will contribute substantially to the output of the panel.

A Questioning Approach: A mind open to new information quickly notices gaps and uncertainties. Both new information and gaps in established patterns of knowledge are powerful stimulants to thinking processes. The man who is always asking questions may have a disquieting influence on those who are sensitive about knowing all of the answers, but he can make valuable contributions.

Acute Powers of Observation: An individual's powers of observation are directly related to his ability to assimilate information. Questions open the door to new information, but highly developed powers of observation are vitally essential to collecting and storing new information. The individual who can only ask questions, who has not developed the ability to gather data and verify this data, must play a minor role in the activities of the panel.

Capacity for Concentration: Concentration provides opportunity for analyzing relationships, visualizing new associations and developing new concepts. Those who have the ability to devote their full attention to a subject for long periods of time are particularly productive of new ideas.

The new-product panel's ability to generate ideas depends directly on its makeup. If the right people are on the panel productivity is assured. To assure output—select panel members carefully.

▶ Fourth Way—Catalyzing Ideas

The fourth way of developing product ideas requires members of the new-product panel to act as catalysts in stimulating the flow of ideas. The function of a catalyst is to accelerate a reaction; here the job is to start a flow of new-product ideas, especially from those individuals who are in a position to make substantial contributions.

The opportunity of tapping the resources of those who are directly or indirectly associated with the corporation's activities should not be overlooked. Anyone whose success is related in any way to the success of the corporation should be willing to make time available to contribute his thinking about possible new-product ideas. One of the new-product panel's jobs is to develop and capitalize these resources.

Who Can Help: People to be cultivated fall into three categories:

1. **Those you sell to—**
   Distributors
   Dealers
   Customers
2. **Those you buy from—**
   Sales representatives
   Technical-staff members
   Executives
3. **Those you work with—**
   Any imaginative talent

Customers, and dealers and distributors who reach the customers, can contribute valuable ideas when they are approached properly. In the course of using almost any product, most people will have ideas about ways the product could be improved. Not only do people have ideas about particular products, but they think of things that they might like to see manufactured. These ideas are worth something to alert manufacturers. It is not easy to get a total stranger to take time to give you the benefit of his thinking, but if gone about in the right way, it can be done. Those who buy, however, are not strangers. They have a stake in the success and the growth of business and can help themselves in the long run by taking time out to pass their ideas along.

Those who are suppliers are in a similar position. From time to time, vendor's executives, technical-staff members and sales representatives develop product opportunities which they don't intend to exploit themselves. These may turn out to be particularly interesting. Certainly they are worth reviewing. Finally, closest to home, the employees of the firm, from the office boy to the board of directors, represent important sources of product ideas.

▶ Tapping the Source

Stimulating a flow of ideas from these sources calls for a carefully planned attack. Ideas start to flow after you do three things: (1) Show people how ideas are important to themselves as well as to you; (2) Invite their aid; and (3) Maintain a climate favorable for the flow of ideas.

Difficulty should not be encountered in showing those who are associated in any way with the firm's business why new ideas are important to both parties. The nature of the common interest should be obvious. Beyond this, a simple request for assistance should be sufficient to enlist co-operation. The request for aid should be a definite plea for help. Many competent people are timid about offering opinions unless specifically asked for their opinions; too often we have all been rebuffed when we have offered unwanted advice. This experience makes even the most callous individual wary of expressing opinions. As a result, in the search for product ideas and suggestions, a very clear and pointed request for help must be made.

Maintaining a climate favorable for the flow of ideas calls for a studied approach. Two considerations are fundamental to the process. First, remember to search for ideas, not screen them. No attempt should be made to evaluate; that comes later. Second, quantity, not quality, is required. The search for ideas should be exhaustive and nondiscriminating.

To put these into practice means that in talking with others they must be drawn out by encouragement and positive stimulation. The following points will be well worth remembering in this connection:

1. Do not criticize, qualify, or express reservations about suggestions that are offered.
2. Acknowledge every suggestion as one having potential merit.
3. Encourage wild ideas.
4. Find an opportunity to read into the suggestion possible combinations and improvements.
5. Give credit for ideas suggested.
6. Ask for expansion upon suggestions.

7. Keep ideas flowing—avoid discussion of technical details.
8. Compliment productivity.
9. Reflect enthusiasm.
10. Show appreciation.

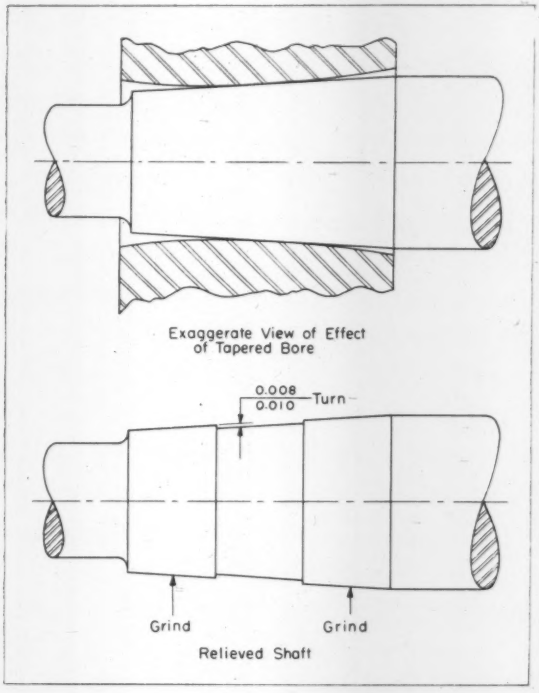
As part of a longer-range program, formalized educational programs can be set up to develop individual and group capacity for creative thinking. The results of such programs have proved rewarding.

Idea Development — A Management Responsibility: New ideas are as important to the long-range growth and development of a business as new customers. The search for both should represent a fixed responsibility. Products have life spans of varying length which can be projected with reasonable accuracy. Such projections serve to emphasize the urgent necessity of recruiting new ideas. Searching for new-product ideas is one of management's most important responsibilities in any corporation where emphasis is placed on growth and stability of profit.

Tips and Techniques

Designing Tapers

A design technique to be remembered when dealing with precision, mating tapered parts is that of relieving part of the surface of the male member. When relieved, the male member will produce a nearly true seat even if the female is not ground perfectly true. The inherent cantilever-beam mounting of the spindle of the internal grinding wheel results in an increased deflection as the grinding wheel progresses deeper into the bore. This may result in a crowned effect in the hub bore which will produce a "rocking" mount of the mating hub and shaft.



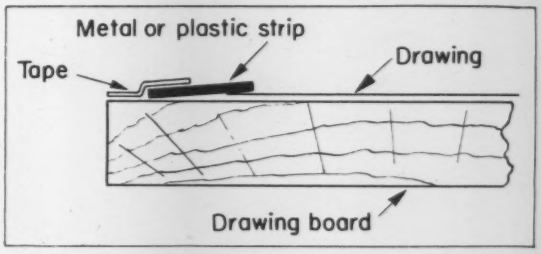
To eliminate this condition, the center portion of the tapered shaft may be relieved by a 0.008 to 0.010-in per side turning operation, as shown. The relief length should be approximately one-third the tapered length. This relief will result in a firm fit of the mating surfaces and a true seat.—GEORGE D. PHEIL, *Racine, Wis.*

Identifying Layouts

Large drawings or layouts are normally stored in rolls. When a particular drawing is needed, it is frequently necessary to unroll a number of them to locate the right one. Much time can be saved if the title, date and drawing or part number are lettered along the edge on both ends of the drawing. Thus, a roll can readily be identified without unrolling, no matter which end it was rolled from.—VINCENT ROSSI, *designer, General Electric Co., Syracuse, N. Y.*

Protecting Drawings

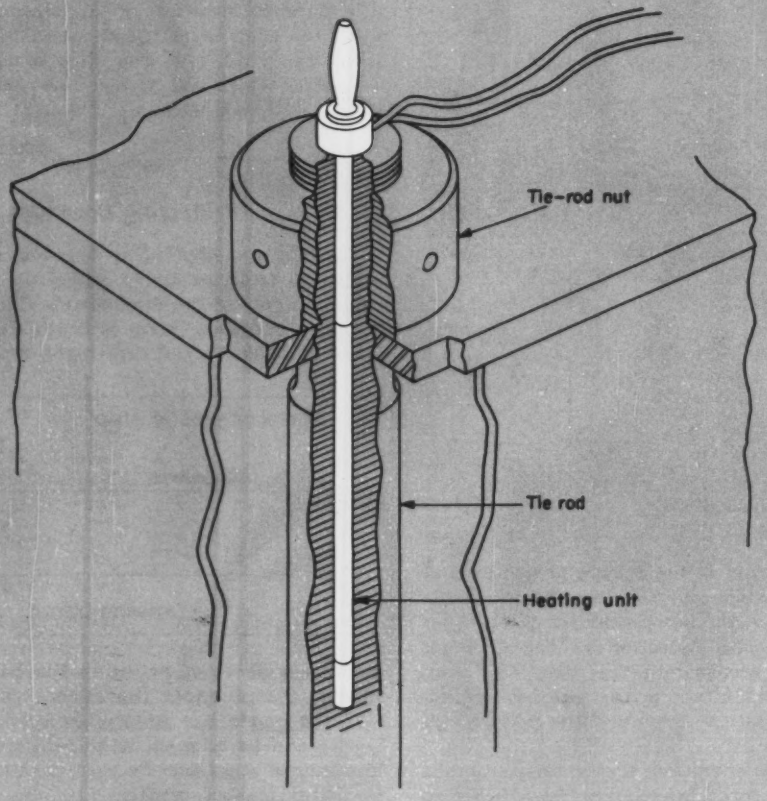
The bottom edge of a drawing can be easily protected from becoming rolled up or torn from being caught by the draftsman's clothing or tools. A metal or plastic strip is taped along one edge, hinge fashion, to the drafting board. When placing a new sheet of paper on the board, its lower edge is placed under the hinged protective strip.

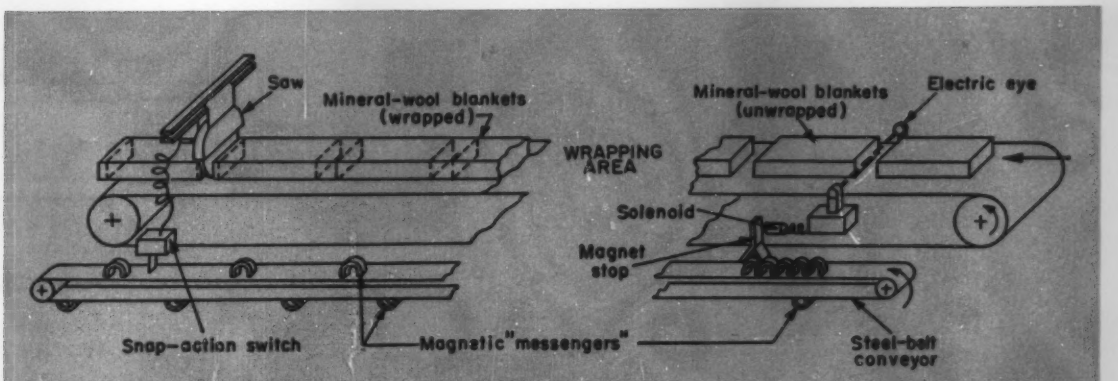


If the paper has preprinted borders, the lower border can be aligned with the edge of the strip. The hinged strip may be then used to set or check the alignment of drafting-machine scales.—A. L. THURSTON, *Los Angeles.*

scanning the field for *ideas*

Electrical shrink-fitting of large tie rods simplifies assembly and disassembly problems. In this design, each end of the tie rod is drilled to accommodate an electric resistance heating unit. The tie rods, used in large presses by the E. W. Bliss Co., are heated uniformly for their entire length by the resistance units. Tie rod nuts are tightened when the rods have expanded a predetermined amount. The heating units are then removed, allowing the rods to cool, shrinking in place to develop the desired tension.

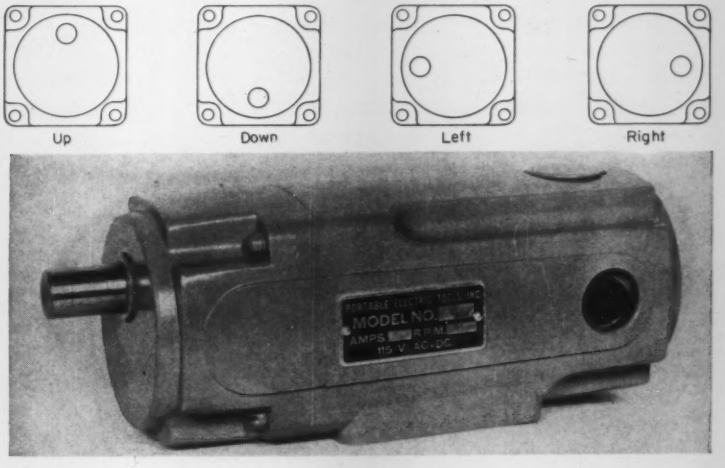


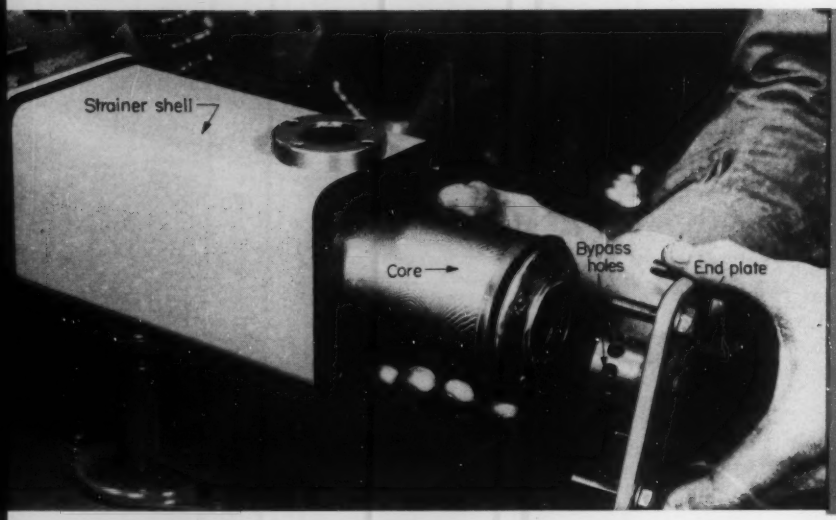


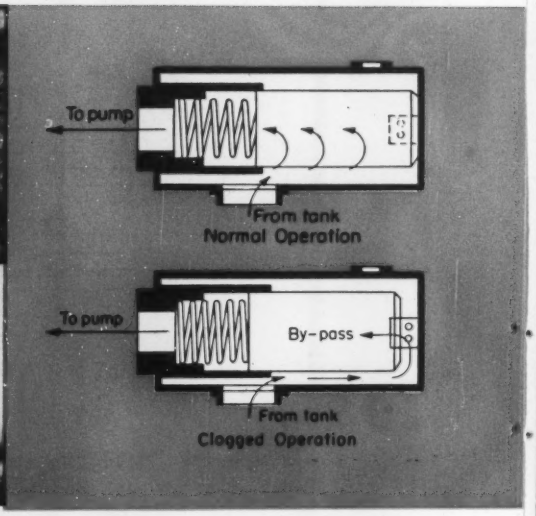
Magnetic "memory messengers" offer a simple but effective approach to programming of variable, automatic indexing or sequencing operations. In a conveyorized processing machine reported by Sanvik Steel Inc., permanent horseshoe magnets are released and permitted to travel along a steel-belt conveyor at irregularly spaced intervals, according to a photoelectric signal. At the exit end of the machine, each magnet acts as a "memory" unit to initiate a final operation in sequence with a program determined by the magnet spacing along the conveyor. The magnets remain permanently on the conveyor and return to the starting point for re-release by the programming device.

In this application, the "messenger" system is employed on a machine that automatically wraps mineral-wool insulation and then cuts the wrapped blankets apart. The wool blankets are in irregular lengths and the spaces between the blankets can not be readily located after wrapping. Spaces between incoming blankets are detected by a photoelectric system and the magnets are released one at a time to carry this information to the cutoff saw at the exit end of the machine. The released magnets, traveling on a steel-belt conveyor at the same speed as the processing conveyor, act as cams to trip a snap-action switch that actuates the cutoff saw. The magnets remain on the steel-belt conveyor and continue around until they reach the input end of the machine, where they are retained by an escapement until released again by the detection circuit.

Symmetrical mounting surfaces on gear-motor casing permit optional assembly of head in four different positions to vary location of output shaft. Designed by Portable Electric Tools Inc., the locating surfaces for joining the head to the motor are symmetrical about both the horizontal and vertical centerlines. This permits locating the output shaft in any of four positions relative to the motor-mounting surface.

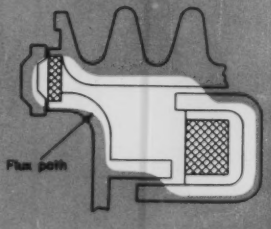


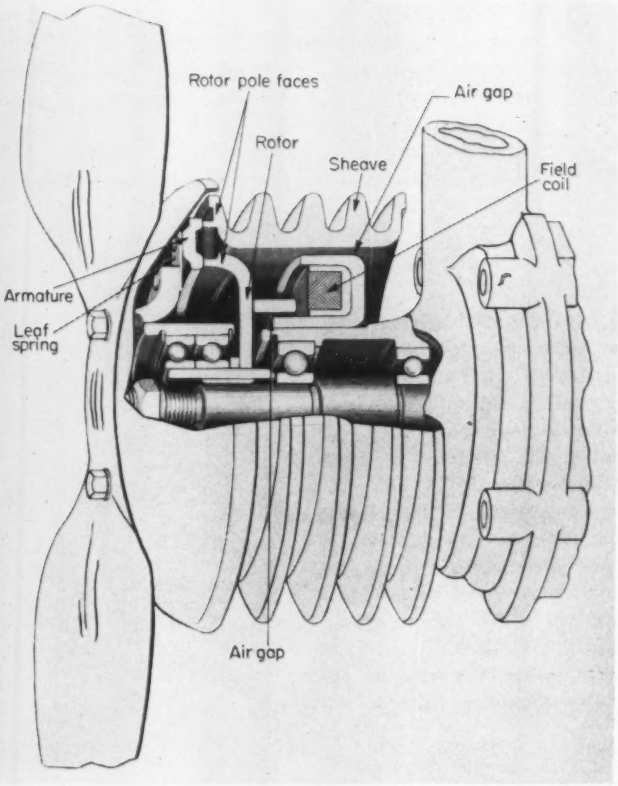




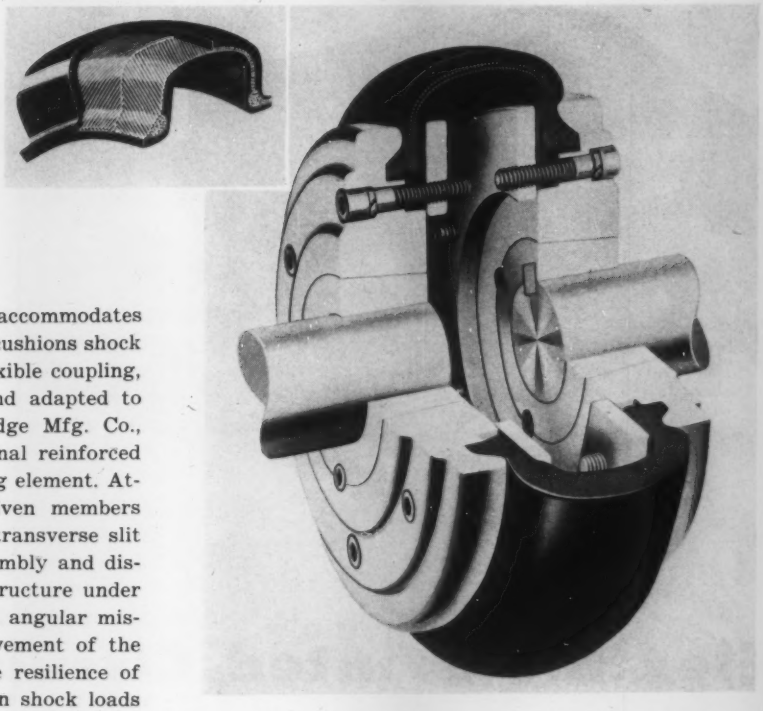
Movable filter core in a strainer assembly permits automatic bypass of hydraulic fluid to prevent interruption of flow when core becomes clogged. Developed by the Rosaen Co., the filter core is normally held in place against the endplate by a coil spring on the pump side. When the strainer will no longer pass fluid, the increased suction of the pump overcomes the spring and causes the core to move away from the endplate. Fluid may then pass through holes in the endplate, permitting bypass operation until core is cleaned or replaced.

Nonrotating field coil in electric-clutch assembly eliminates the need for conventional collector rings, slip rings, or brushes. The coil of the Warner electric fan clutch, designed for use on internal-combustion engines, is connected directly to the voltage source. The rotor of the clutch is concentric with the field coil and is fastened to the driven sheave. The armature is mounted on the driven fan hub with leaf springs. When the field coil is energized, the springs flex and the armature becomes magnetically coupled to the rotor, engaging and driving the fan.





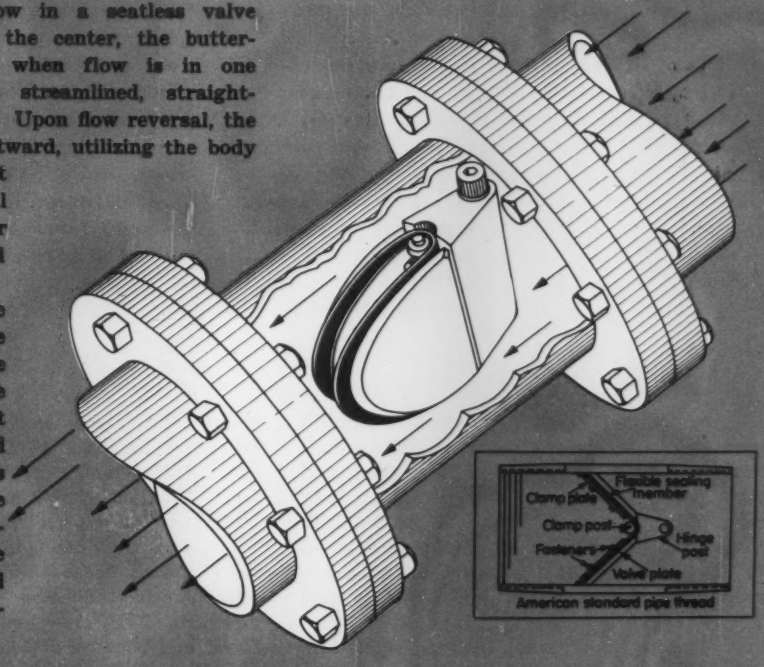
ideas

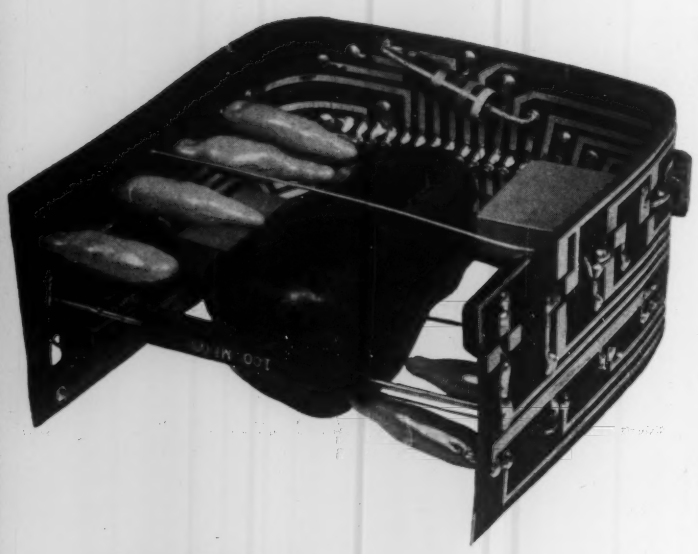


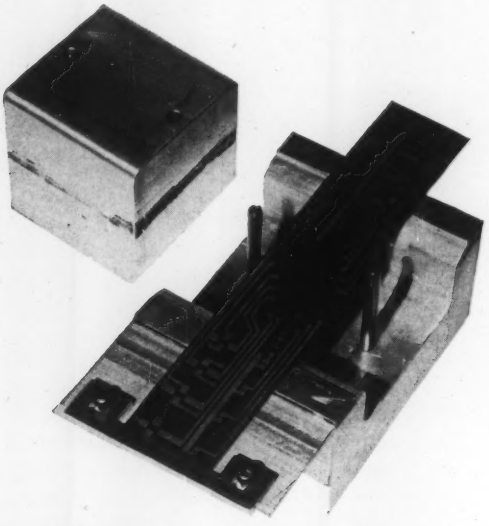
Rubber-tire drive joint accommodates misalignment and end-play and cushions shock and vibration. The Para-flex flexible coupling, developed in West Germany and adapted to American requirements by Dodge Mfg. Co., uses a rubber tire of conventional reinforced design as the power-transmitting element. Attached to the driving and driven members by clamp rings, the tire has a transverse slit molded into it to facilitate assembly and disassembly. Flexing of the tire structure under load accommodates parallel and angular misalignment as well as axial movement of the drive members. In addition, the resilience of the tire material acts to cushion shock loads and torsional vibrations.

Hinged butterfly plates control direction of fluid flow in a seatless valve design. Hinged in the center, the butterfly plates collapse when flow is in one direction, giving a streamlined, straight-through liquid path. Upon flow reversal, the two plates swing outward, utilizing the body of the valve as a seat and providing full closing with either high or low fluid pressure.

Developed by the Techno Corp., the butterfly plates are actually a one-piece flexible member that both forms a fluid seal and acts as its own hinge. Valve plates and clamps reinforce the flexible member and add weight to assist operation.







Applying
Flexible Printed Circuits
in electronic-equipment design

Thin, flexible printed circuits are now being applied successfully in electronic equipment packaging. Thin wiring boards are of value primarily because of their heat-formable properties. In suitable packaging applications, flexible wiring cards offer substantial economies in fabrication and assembly, but such cards have limited usefulness as rigidizing or ruggedizing members. Electronic packages incorporating flexible laminated boards can be made shock and vibration resistant through encapsulation in casting resins or rigid foams.

In this article, application of flexible printed circuits in electronic packaging is discussed first. In design, the wiring is printed

As a result of increased application of printed circuitry in recent years, the need for metal-clad laminates of improved electrical and mechanical properties and greater versatility has also grown. Thin, flexible laminates, Figs. 1 and 2, have been developed as a result of this demand and are at least a partial answer to the problems created by complex electronic circuitry and miniaturization.

Flexible laminates are, in general, dielectric types of materials reinforced with glass fabric, paper, or thermoplastic fabrics of nylon, Orlon, or Dacron. They are held together by a binder, usually either an epoxy or a phenolic resin. The laminates discussed here are produced with one of the reinforcements mentioned above and epoxy resin. Flexible, clad Teflon glass and Kel-F glass laminates have been marketed for a number of years, but their acceptance and application have been limited because of their high cost and the unpredictable adhesion of the conductor to the dielectric. Thin epoxy-glass laminates are easy to form, and because of this, will probably be widely used in electronic-equipment packaging.

The thin, printed-circuit card, Fig. 1, is indispensable in any electronic-equipment package re-

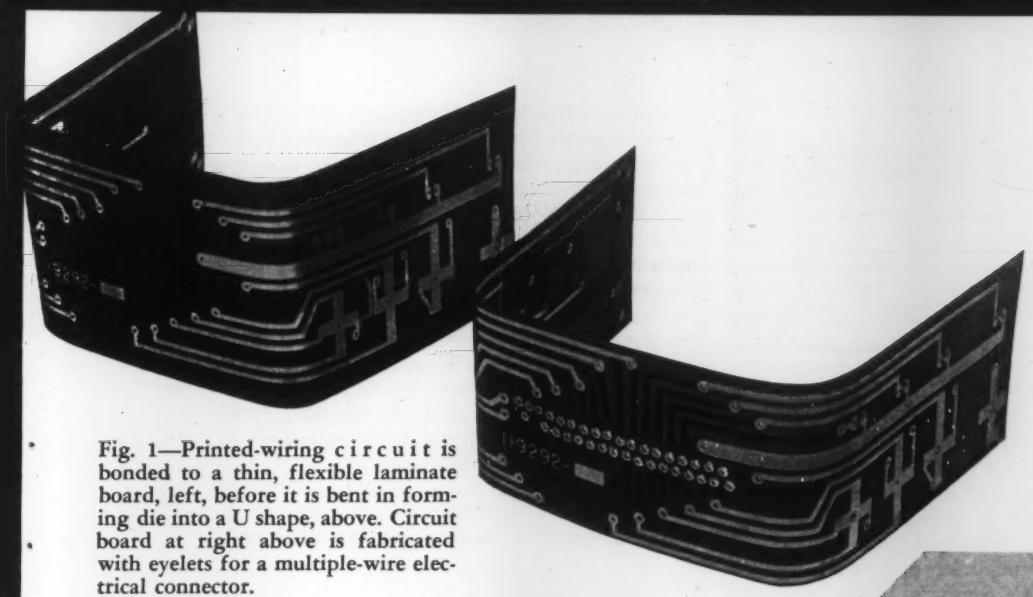


Fig. 1—Printed-wiring circuit is bonded to a thin, flexible laminate board, left, before it is bent in forming die into a U shape, above. Circuit board at right above is fabricated with eyelets for a multiple-wire electrical connector.

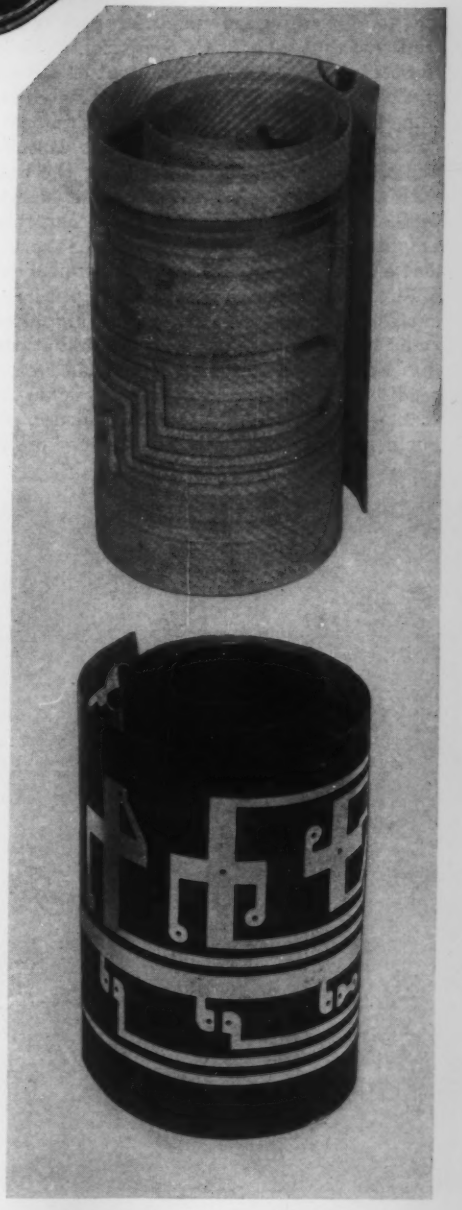


Fig. 2—Spirally shaped printed circuit. This design is particularly applicable in the design of electronic assemblies that must be cylindrical in shape.

By George Voida
Sandia Corp.
Albuquerque, N. M.

on thin copper-clad laminates which are made principally of epoxy resins and reinforcement materials. Specifically considered here are types of materials and their commercial availability, conductor-laminate bond-strength properties, shaping characteristics, and processing and operating stability.

quiring maximum wiring reliability, and where the board must turn corners, fit around components, conform to the configuration of the chassis, or fit within a minimum volume. The U-shaped design, Fig. 1, is an excellent example of the intrinsic value of the flexible printed circuit. The single card not only replaced six separate boards in one application, but also eliminated 40 different soldered connections for interconnecting these boards and significantly increased the reliability of the printed circuit. Critical alignment tolerances of the two superimposed connector boards formerly used across the base of the U were also eliminat-

Table 1—Weights and Thicknesses of Copper-Foil for Printed-Circuit Applications

Approx. Weight (oz/sq ft)	Nominal Thickness (in.)	Thickness Tolerances (in.)
1	0.0014	+0.0004, −0.0002
2	0.0028	+0.0007, −0.0003
3	0.0042	+0.0009, −0.0004

ed. Since only minor fabrication problems have been encountered in the preproduction stages of two different packages in which U-shaped boards were used, the flexible-card design illustrates the adaptability of this system to mass assembly.

The flexible card is also being considered for use in a strain-gage amplifier package. This design requires that the components be arranged to occupy about 75 to 80 per cent of the cylindrical space formed by the card. This printed-circuit arrangement is expected to eliminate some intricate wiring problems, materially reduce assembly costs, and make it possible to distribute the components within the available space to avoid hot-spot problems. Use of the flexible-card technique in this amplifier package is expected to make it economical enough to be used as a throw-away item.

Flexible laminates may prove to be suitable in such commercial applications as amplifiers, small radio transmitters and receivers, miniaturized hearing aids, and shields. They may also be useful as modular or plug-in subassemblies in television transmitting equipment, communication systems, business machines, and switching or recording equipment. For such applications it may be necessary to design the subunit so that individual components are readily accessible either for repair or replacement purposes.

Pliability of the printed circuit may be significant in the production of microwave assemblies, in antennas, and in conductor-insulator strips for current-carrying or heat-transmission purposes.

Flexible printed circuits may also be incorporated in expendable subassemblies used in radio-sound equipment, aircraft equipment and guided missiles. In all of these applications, the subunits would be strictly throw-away items encased in casting resins or foams to protect the components against various environmental hazards.

Design and Fabrication Requirements

Before designing a flexible printed circuit into an electronic package, it is necessary to evaluate carefully its suitability for the specific application. A number of limitations are imposed on the material because of its flexibility: (1) it is not a rigidizing member, (2) it may not be used as a supporting member for heavy components, and (3) it is unsuitable if unsupported for use where shock and vibration predominate.

How heavy a component must be to be considered unattachable to a flexible printed circuit is difficult to answer in specific terms of weight. Size of the package, distribution of the weight

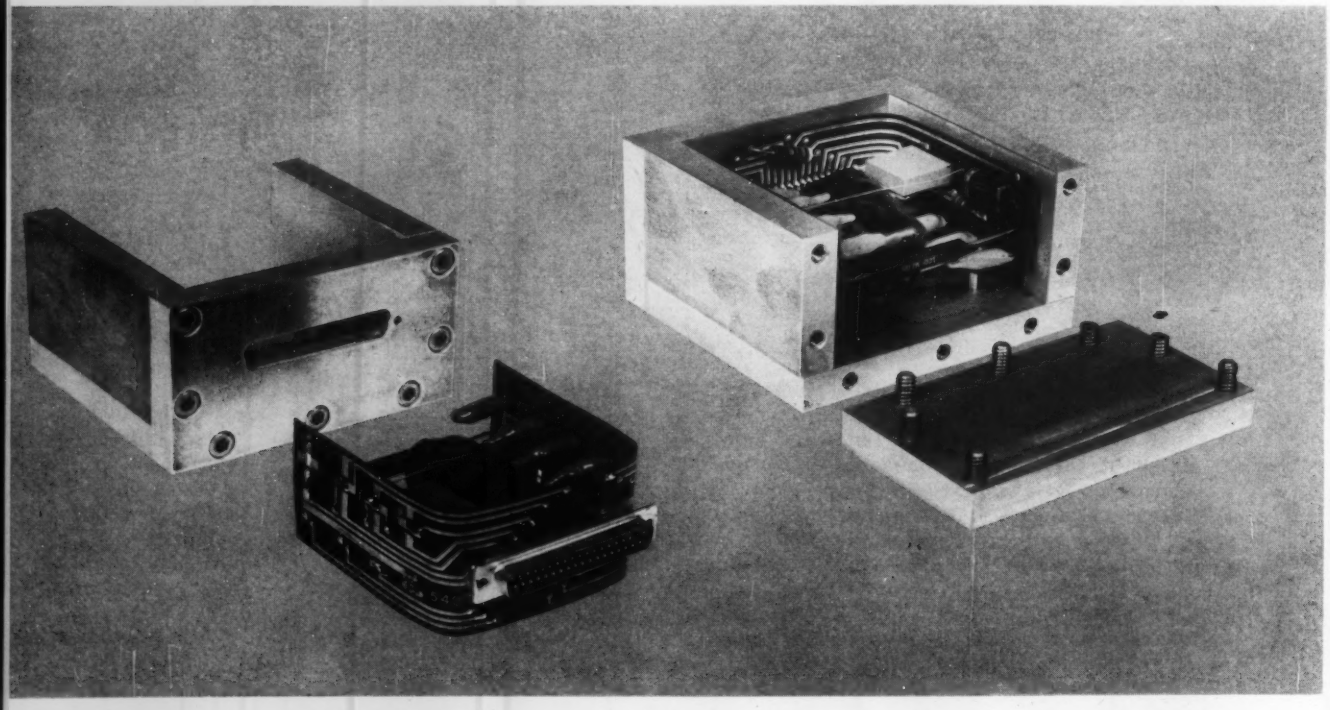


Fig. 3—Electronic subassembly and mold box for encapsulating unit in plastic. Note opening for electrical connector.

of the components, methods of mounting, and environmental requirements must all be considered in the analysis. On the basis of assembly information now available, it is difficult to formulate even an empirical rule. As a rule-of-thumb, if in the course of normal fabrication the package can be picked up and supported by any portion of the printed circuit without distorting the card or breaking the soldered joints, the unit may be considered within the proper weight limits.

In some applications, overweight components would be externally supported independently of the printed card. Under these circumstances stresses on card and soldered connections would be eliminated. This would also apply to packages which are to be potted or encased. In Fig. 3 is shown a typical electronic subassembly and a mold box for potting the unit.

▶ Types of Flexible Laminates

Only a few fabricators are now producing thin or flexible-clad laminates. As the versatility of these materials becomes better known, more suppliers will probably establish them as stock items to meet the demand. Evaluations of various flexible laminates are presented here, and data are based on actual tests made by the author.

In general, clad materials of this type are available with either 1 or 2-ounce copper conductor bonded on one or both sides of the laminate. Clad products with 3-ounce copper can be obtained on special orders, but these are not recommended for designs in which the inherently pliable and formable characteristics of the material are needed. Table 1 lists weight and thickness data on copper foil.

Glass-Fabric Reinforced Laminates: Glass-epoxy laminates were found to be superior to the other materials investigated in fabrication qualities. This group is, therefore, recommended for general application in printed circuitry.

In Table 2 are listed construction and flexibility properties of four types of glass-fabric epoxy-impregnated reinforced laminates. Laminate A is unique in that it can be formed at room temperature. Bends can be made either manually or mechanically, and they will retain their shape even after extended period of storage at room temperature. Some formed printed-circuit boards were placed on edge in an oven at 165 F for ½-hour and showed no tendency to relax. Prolonged exposure at this temperature would undoubtedly produce advanced postcure. Laminate A boards were postbaked at 250 F for 30 minutes. The laminate did not change shape, but it did become sufficiently postcured to make further bending and forming impossible.

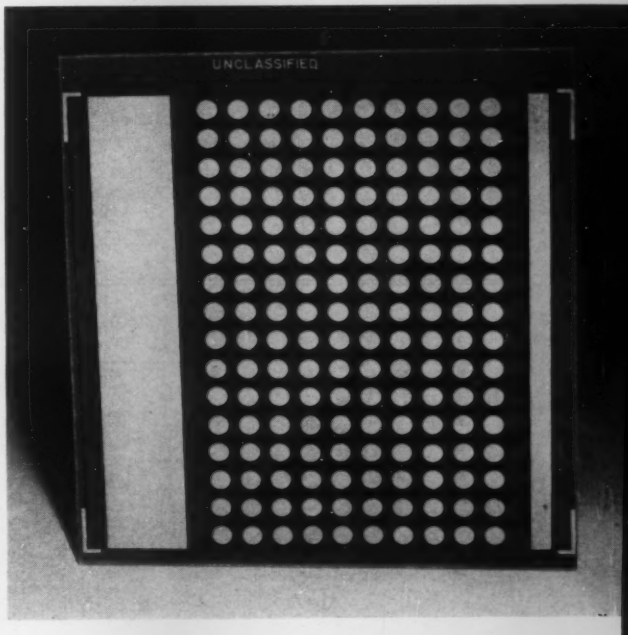
Clad-epoxy laminates B and C have similar physical characteristics and are equally formable. Both require identical preheating conditions for formation, and each becomes slightly misshaped when exposed to temperatures as high as 165 F. The boards can, however, be rebent to the desired configuration because slight relaxation and deformation does not affect the pliability of the laminate in the bend areas. When these materials are postcured for about 1 hour at 250 F, they become rigid enough to prevent further bending or forming. If bending is attempted at this stage, the glass plies will delaminate and the conductor will crinkle and separate from the dielectric base.

Clad laminate D, which was also of a glass-epoxy construction, was considerably different from the other materials just described. To form this material, temperatures 100 to 150 degrees higher than those used for laminates B and C are needed. Even at these higher temperatures, laminate D is not sufficiently pliable to be shaped without fracturing and delaminating. It was, therefore, assumed that this laminate was constructed of coarser glass-fabric plies or that a greater number of plies were used. However, pyrolysis, recovery, and

Table 2—Construction and Flexibility Properties of Epoxy-Glass Laminates

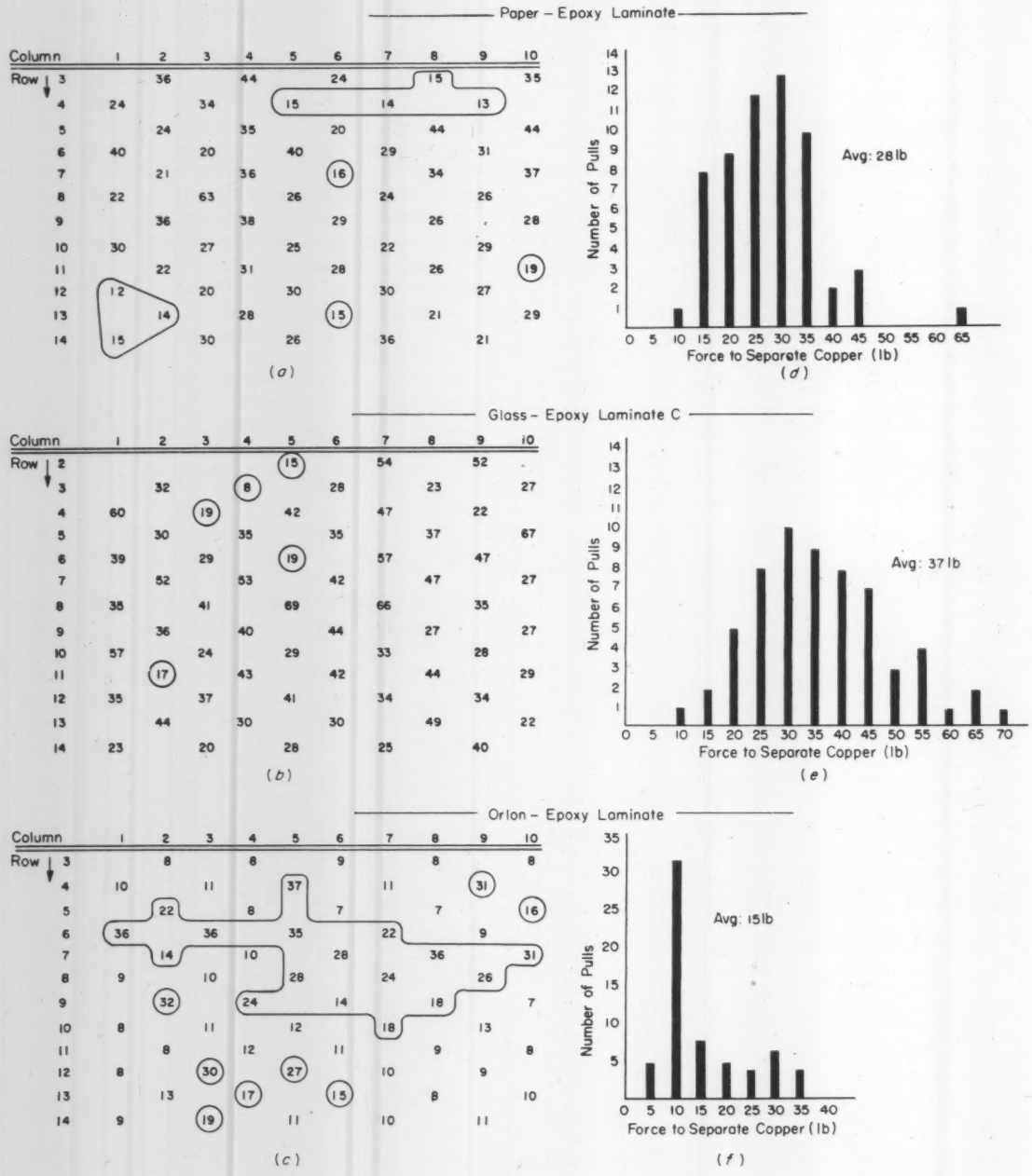
Laminate	No. of Plies	—Ply Thickness— (mils) No. 1	No. 2	No. 3	Overall Thickness (mils)	Laminate Formability
A	1	4	–	–	4.0	Room temp. formable
B	3	4	8	4	20.0	Heat formable
C	3	4	8	4	18.5	Heat formable
D	3	4	8	4	16.5	Nonformable

Fig. 4—Typical pull-test specimen for determining conductor-laminate bond strength.



gaging tests on the separate glass reinforcements showed that the laminate construction and the ply thicknesses were identical with those of laminates B and C. Data in Table 2 give details on the construction of the four epoxy-glass laminates, and reveal that the type, number, and thickness of the reinforcement are not necessarily the factors which govern the flexibility of the materials. Flexibility of the laminates is, therefore, obviously determined by the state of cure of the resin binder and to some limited extent by the type of reinforcement used. Flexibility and formability of the epoxy-glass laminates may have occurred without any design on the part of the fabricators. To retain

Fig. 5—Distribution of pull values in pounds over a 3 by 3-in. test board made of paper-epoxy laminate, *a*, glass-epoxy laminate, *b*, and Orlon-epoxy laminate, *c*. Frequency distribution of pull-test values for the paper, glass and Orlon-epoxy laminates are shown in charts *d*, *e* and *f*, respectively.



these desirable properties and their reproducibility in subsequent production lots, it may, therefore, be necessary to define the desired intermediate state of resin cure in a formal NEMA or MIL specification.

Orlon-Fabric Reinforcement: The Orlon-epoxy laminate is available in a thickness of 10 to 12 mils with either 1 or 2-ounce copper on one or both sides of the dielectric. The Orlon fabric could not be removed from the laminate tested to determine whether the laminate consists of a single-ply or multiple-ply construction. Visual inspection, however, indicated that the construction is single layer. The Orlon epoxy required heat for shaping, was distortable if exposed to elevated temperatures, was reformable on the application of heat, and was postcured to nonflexibility on exposure to 250 F. Processing Orlon-epoxy boards and assembling them into electronic packages demonstrated that they had greater dimensional instability and heat sensitivity as compared to glass-epoxy types. For these reasons, the Orlon-epoxy laminates cannot be used as widely in high-temperature wiring applications as can the glass epoxies.

Nylon-Fabric Reinforcement: Many producers carry nylon-phenolic laminates as a stock item. It is obtainable in a minimum thickness of 15 mils. For this investigation, a 1/32-inch thick laminate was evaluated. The nylon phenolic is heat-formable under the conditions described for the epoxy laminates. Although not as widely used as the epoxy laminates, nylon-phenolic laminates are electrically superior to the epoxies.

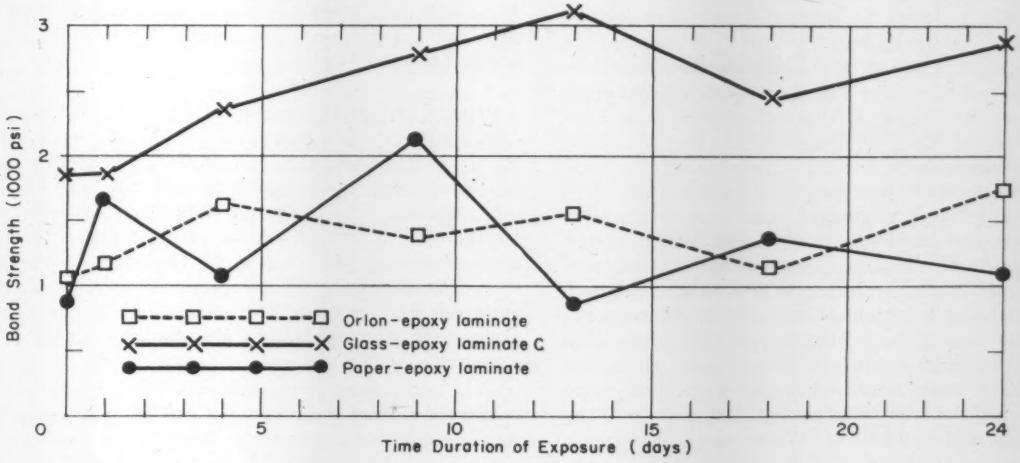
Paper Reinforcement: Thin-paper epoxy laminates must be handled carefully during fabrication to prevent fracturing at the bends during forming. If the material is to be drilled or punched, care is needed to prevent the laminate from fracturing around the hole. When postcured, the laminate becomes extremely brittle, although the advanced cure greatly improves the conductor-laminate bond strength as will be shown later in this article. Because of the mechanical disadvantages of the thin-paper epoxy laminate and the slight cost differential when compared with epoxy-glass, the thin-paper epoxy laminate is not recommended as a wiring card in electronic equipment.

General Remarks: Pliability of the thin laminates is largely determined by the degree of cure of the resin binder and by the type of reinforcement employed. Materials such as the Orlon-epoxy and glass-epoxy laminate A can be formed at room temperature. The Orlon-epoxy material exhibits pronounced recovery unless it is simultaneously postcured upon formation. Laminate A showed almost no relaxation if it is shaped at room temperature and then postcured. The formable materials can be bent to a radius of 1/32-inch without difficulty.

▶ Shaping Characteristics and Flexibility

When the formable laminates are heated, they soften considerably and can be shaped into various configurations, Figs. 1 and 2. Preheating at 250 to 300 F for 1½ to 2 minutes produces the required softening. One printed-circuit card tested was placed in a forming device and shaped by mating the two sections of the tool, Fig. 1. No portion of the tool was heated, and shaping had to be performed rapidly before the heat dissipated from the card. To minimize relaxation or springback of the printed circuit after forming, it is advantageous to employ a nonheated tool. The entire forming operation must be performed in about 5 to 10 seconds. Even though the card is positively aligned and centered in the tool, the formed state

Fig. 6—Effects of an elevated temperature of 240 F on conductor-laminate adhesion.



may not always be symmetrical because of slippage which occurs when tool parts are mated. Lubrication of the tool surfaces with silicone grease helps to reduce drag of the conductor pattern over these surfaces.

The technique described in the previous paragraph was used to form a card with eyelets crimped in place, which is also illustrated in Fig. 1. This card was formed with the forming tool shown in Fig. 1, but this tool would not be satisfactory except for experimental use because there is not enough clearance between its parts. It would be advantageous to put the eyelets into the card before it is formed if circumstances permit, because posteyeletting may present some perplexing insertion and crimping problems. In designing postformable printed circuits, it is necessary to locate eyelets away from the immediate bend regions.

The spirally shaped cards, Fig. 2, were first preheated at 250 F for a few minutes, then concentrically wound while still hot with a ⅛-in. thick Silastic spacer, secured to prevent unravelling, and postcured for about 30 minutes at 250 F. A spiral printed circuit is particularly useful in designing for confined cylindrical packages and miniaturization.

Heat-Resistance Characteristics

Thin laminates, particularly those containing thermoplastic reinforcements, such as Orlon, nylon, and Dacron, must not be exposed to excessive temperatures. These materials shrink appreciably, if the temperatures during photoprocessing, etching, postcleaning, and soldering are not controlled. For example, it has already been observed that Orlon epoxy shrivels noticeably and shrinks about 1 per cent when exposed to the hot fixing temperatures of the etch resist at 425 F for about 2 minutes or when exposed to the hot-solution treatment used to remove the resist. Dimensional changes of this magnitude would make a printed-circuit card unusable when close tolerances must be maintained and multiple-wire components are used in the package.

The Orlon-base epoxy is also affected by the heat needed for manual soldering. Special precautions must be used to prevent direct contact between the soldering-iron tip and any portion of the dielectric. If physical contact is made, the laminate will discolor. The degree of discoloration indicates the degree of thermal degradation. Discoloration is, thus, a measure of the dielectric and insulation impairment of the material. Any adverse exposure of this nature must be avoided.

Fluxes are not, in general, injurious to the electrical or the structural properties of an epoxy laminate if its surface is unmarred. If, however, the surface of the laminate is broken or ruptured, a plasticizing reaction of the rosin constituents with the epoxy-resin binder results. When this occurs, the surface structure of all epoxy laminates is severely deteriorated within a short time without regard to the reinforcing materials or the environmental conditions. When epoxy laminates with maximum thermal resistance are required because of processing and assembly conditions, it is advisable to select epoxy-glass as the printed-circuit material.

Conductor-Laminate Bond Strength

Variations in conductor-laminate bond strength are caused by a complex set of factors. Materials used in the product affect the bond strength. The characteristics of these materials can be changed during fabrication, processing, and assembly. And finally, the characteristics of the material may be changed by the environments in which work is done. All of these factors combine to determine the bond strength of the final product.

Clad-Laminate Fabrication: Since the quality of adhesion is influenced by the specific properties of the separate constituents of the clad-product, it is essential to consider the physical and chemical behavior of the parts before and during fabrication into a finished product. The history of each of the materials before it is incorporated into the laminate is important. If, for example, the glass-fabric reinforcement is improperly desized, improperly finished, insufficiently dried, contaminated, haphazardly impregnated, or has variable thickness, it is apparent that adhesion may be seriously affected by any one of a number of deficiencies of a single constituent. In epoxy-glass laminates sources of flaws which jeopardize adhesion are:

1. Surface treatment of the glass reinforcement.
2. Impregnation of the reinforcement.
3. Volatiles in the resin binder.
4. Plasticizers in the resin binder.
5. Thickness uniformity of the adhesive, if used.
6. Volatiles in the adhesive.
7. Thickness uniformity of the copper conductor.
8. Prepriming and priming treatments of the copper surface.
9. Contamination of materials.
10. Time, temperature, and pressure during cure.
11. Thickness and density of the resin adhesive at the copper-reinforcement interface.
12. Overall thickness uniformity of the clad laminate.

The variety of these sources illustrates the necessity for maintaining uniformity if uniform adhesive properties are to be produced.

Printed-Circuit Processing: During photoetching, adhesion can be severely degraded if the resin at the copper-laminate interface is sensitive to (1) elevated temperatures, (2) moisture, (3) etching solutions, (4) solvents for removing resists, (5) plating solutions, or (6) any of these fluids in combination with elevated temperatures. Poor adhesion caused by photoetching is usually characterized by blistering and separation of the conductor and can readily be detected by visual inspection.

Printed-Circuit Assembly: If adhesion is poor, it may deteriorate even more if the card is flexed

during processing or assembly, exposed to molten solder or to the various fluxing agents, or brought in contact with flux removers.

Bond-Strength Evaluation Data: Conductor-laminate bond strength is a controversial subject because of the many factors that influence adhesion and because of the variety of methods used to evaluate the strength of adhesion. No attempt will be made here to judge the merits of the different test methods. Comprehensive data obtained by the spot-pull test method are, however, rather revealing and interesting. By the spot-pull test method, bond strength is determined after the printed circuit has been exposed to all of the processing and assembly environments and thus is a precise measure of ultimate adhesion reliability. These data should be carefully analyzed in order to judge the merits of this procedure versus the widely accepted peel method.

A typical specimen is shown in Fig. 4 which was used to measure bond strength. The ⅛-in. circular areas on the card were produced by photoetching. The thin cards were bonded to an epoxy-impregnated glass-fabric laminate that was 1/16-in. thick to give them the rigidity needed in testing. A wire was soldered to the ⅛-in. land so that it was perpendicular to the card. When the card and the attached pull wire were brought to equilibrium at room temperature, the specimen was secured in a tensile-strength machine.

A force increasing uniformly at the rate of 0.5-lb per second was applied through the wire to the ⅛-in. conductor area. The force was exerted in a plane perpendicular to the plane of the printed-circuit board. The force in pounds at the instant of separation of the copper or rupture within the laminate surface was recorded as the bond strength between conductor and dielectric. Epoxy laminates in general, however, broke down within the laminate rather than separating at the "glue-line," as might have been expected. The actual bond strength in most cases, therefore, exceeds the values reported here.

Bond values in pounds at numerous points over 3 by 3-inch boards tested are shown in Figs. 5*a*, *b* and *c* for paper, glass and Orlon-fabric epoxy-impregnated laminates, respectively. The bond-distribution values of the laminates reveal the randomness with which subnormal adhesion occurs over the specimen. Poor adhesion, since it does not conform to an established pattern, is attributed to the fabrication irregularities which were enumerated earlier. Despite these persistent materials and fabrication variables, reproducible bond-strength values of about 45 pounds can and have been produced commercially and can be expected when epoxies are used as the binding and the adhesive agents.

Frequency-distribution plots of laminate-bond-strength values are shown in Figs. 5*d*, *e* and *f*. Note that the frequency-distribution plot for the glass-epoxy laminate C closely resembles a normal distribution curve and that only three pulls were less than 19 pounds. The average bond-strength value for laminate C was 37 pounds which is equivalent to almost 3000 psi.

Bond-strength values of the Orlon-epoxy laminate are plotted in Fig. 5*f* on a scale different from those of the other laminates. The skewed distribution may be an indication of the predominating influence of the thermoplastic reinforcement on adhesion.

Six specimens were exposed to 240 F to determine the effects of elevated temperature with time on the adhesion of the copper to the laminate. Heat had a beneficial effect on adhesion. The maximum effect was produced within 4 to 24 hours at 240 F, and the bond strength improved by as much as 30 to 100 per cent, Fig. 6. Each point on the graph represents an average of five pull-test values. These values conform generally to the frequency-distribution plots shown in Figs. 5*d*, *e* and *f*. Since almost insignificant degradation in adhesive strength occurred after 2 weeks of exposure at 240 F, it is evident that the bond has satisfactory high-temperature resistance.

Effects of thermal cycling on adhesion were also studied. Each cycle consisted of exposure for 3 hr at 165 F and 3 hr at −65 F. The specimens were transferred immediately from the elevated to the subzero temperature and were permitted to attain room-temperature equilibrium before pull testing was conducted. Change in adhesion with cycling was graphed, and each plot represented the average of five pull-test values. In general, adhesion showed a steady improvement with cycling, but a downswing in adhesive strength occurred after 15 cycles. Similar behavior after 20 to 40 cycles was noted in previous investigations with XXXP, nylon-phenolic, and epoxy-glass laminates. But upon further cycling up to 90 complete cycles, the bond strength increased steadily. There is no explanation for this phenomenon at the present time, but it may be stated that for practical purposes thermal cycling has no deleterious effects on adhesive strength.

Tips and Techniques

Making Templates

Drawing templates may be easily made from 0.020-in. thick acetate sheet stock. The acetate is scored with a sharp scriber or razor blade to the desired shape and the material is pushed out of the template by heavy finger pressure, similar to the method used in cutting window panes. The outline of the desired shape is left. The edges are then sanded lightly to give a smooth edge for the pencil point to follow when drawing. The length and width of the opening should by 1/64-in. larger than the nominal size for a pencil allowance.—A. E. MAGISTRO, *Landing, N. J.*

Quantitative design of

SERVO SYSTEMS

Part 1—Terms Affecting Gain and Phase

QUESTIONS of improving the performance and stability of closed-loop systems by the addition of elements having special characteristics were discussed in earlier articles.[1-13] Two approaches were outlined: (1) modifying the network in cascade with other elements in the forward path, and (2) modifying elements in a subsidiary feedback loop, Fig. 1.

In each of these diagrams $Y_o(s)$ represents the transfer function of the forward path before the modifying elements are added. It will consist mainly of terms due to the lags inherent in the amplifier-motor system. These lags cause performance to deteriorate, and if performance requirements cannot be met, suitable networks must then be devised to compensate for any deficiencies.

A qualitative approach was made to this problem in the last article, showing that in many cases deficiencies can be remedied by using certain standard-form networks—for example, proportional-plus-derivative (phase advance) and proportional-plus-integral. In a specific design problem, it is necessary to assign definite values to network parameters not merely to specify the form of network required. This should be done in a methodical and simple fashion if possible. The purpose of this article is to outline some short-cut methods which yield, often by approximation, values for network parameters very rapidly. Of equal importance is that these methods often suggest the form of the compensating network required. The errors introduced by approximation are usually unimportant in making initial design calculations.

[1]References are tabulated at end of article.

Logarithmic Response Curves: The loop response function for a single-loop system having only lag terms has been found to be of the general form,

$$Y_o(j\omega) = \frac{K}{(j\omega)^r(1 + j\omega T_1) \ldots (1 + j\omega T_2 + \omega^2 T_3^2) \ldots} \quad \ldots (1)$$

In general there will be a number of simple and quadratic lag terms in the denominator. A direct assessment of system performance can be made by plotting the locus of vector $Y_o(j\omega)$. One way of doing this is to obtain expressions for the amplitude ratio $N(\omega)$ and phase $\psi(\omega)$, relating output θ_o to error e for sinusoidal signals. These are respectively the modulus and argument of $Y_o(j\omega)$. It will now be shown that by taking the logarithm of $Y_o(j\omega)$ the determination of amplitude and phase characteristics can be greatly simplified:

$$\log Y_o(j\omega) = \log [N(\omega)e^{j\psi(\omega)}] = \log N(\omega) + j\psi(\omega) \quad (2)$$

It is convenient to separate real and imaginary parts and to plot log N and ψ separately against frequency ω. That is, if $Y_o(j\omega)$ is the product of

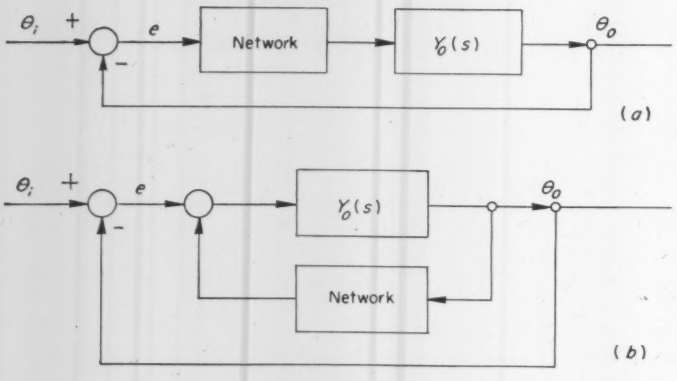


Fig. 1—Two possible methods of improving performance. At *a*, modifying network is cascaded with main loop elements. At *b*, modifying element is placed in subsidiary feedback loop.

by frequency-response methods

By J. M. Nightingale
Manchester, England

the transfer functions $Y_1(j\omega)$, $Y_2(j\omega)$, . . . , of a number of elements in cascade, then

$$\left.\begin{aligned}\log N(\omega) &= \log N_1(\omega) + \log N_2(\omega) + \dots \\ \psi(\omega) &= \psi_1(\omega) + \psi_2(\omega) + \dots\end{aligned}\right\} \quad (2)$$

where N_1, ψ_1 are the modulus and argument of $Y_1(j\omega)$, and so on. Quantities such as $\log N_1$ are generally called the gain of the particular element, while $-\log N_1$ is called its attenuation. Thus to find the gain and phase of a system composed of a number of elements in cascade it is merely necessary to add the respective components of all the elements in the chain.

While there is no objection to using natural logarithms to define gain, it is more common among engineers to choose a base of 10. Then, following practice adopted in other fields, gain is defined as

$$A(\omega) = 20 \log_{10} N(\omega) \quad (4)$$

Although this is only a numerical quantity, it is usual to assign units called *decibels* to this quantity. Thus, if at a certain frequency a device has an amplitude ratio N of 100, its gain at that frequency is 40 decibels (db). If over a certain frequency range the gain increases by 20 db, then the amplitude ratio at the frequency at the end of the range is ten times the value at the initial frequency. If the gain at one frequency is double

Nomenclature

$A(\omega)$	= Loop gain in decibels
$A_1(\omega), \dots$	= Gains in decibels
a	= Constant
e	= Error
H	= Constant
K	= Scalar gain constant
k	= Constant
$M(\omega)$	= Overall amplitude ratio
$N(\omega)$	= Loop amplitude ratio
$N_1(\omega), \dots$	= Amplitude ratios
n	= Constant
$p_1, \dots$	= Poles
r	= Order of servo
s	= Laplace operator
T	= Time constant
$T_1, \dots$	= Time constants
u	= Nondimensional frequency variable
x	= Nondimensional frequency
$Y(s)$	= Transfer function
$Y_o(s)$	= Loop transfer function
$Y_o(j\omega)$	= Loop harmonic response function
$Y(s)$	= Transfer function
$z_1, \dots$	= Zeros
$\psi(\omega)$	= Loop phase angle
$\psi_1(\omega)$	= Phase angles
θ_o, θ_i	= Output and input
ω	= Frequency variable
$\phi(\omega)$	= Overall phase
τ	= Time delay
ζ	= Damping ratio

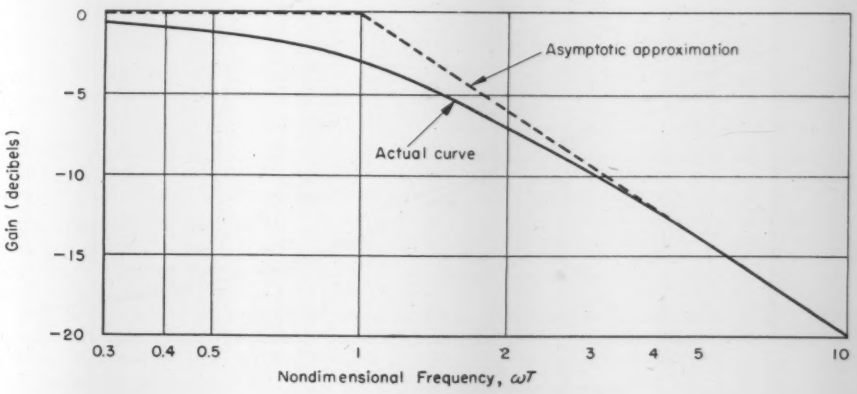


Fig. 2—Plot of gain characteristics for simple lag term. Actual curve may be approximated by straight-line segments, but this will involve an error, not more than 3 db, which should be corrected when an accurate plot is made.

the gain at another frequency, then the amplitude ratio at the first frequency is the square of the amplitude ratio at the second frequency.

Further advantages of logarithmic plots are available if a logarithmic frequency scale is also chosen. Thus the abscissas x of the plots should be expressed in terms of nondimensional frequency

$$x = X \log \left(\frac{\omega}{\omega_o} \right) \qquad (5)$$

where ω_o is the frequency chosen at $x = 0$, and, if logarithms to the base 10 are used, X is the value of x corresponding to $\omega = 10\omega_o$.

The need to graduate a frequency scale using Equation 5 is unnecessary if graph paper is available whose horizontal scale is graduated logarithmically, Figs. 2, 3, 4. In this case frequencies can be marked directly starting with a sufficiently low frequency ω_o. The frequency range ω_o to $10\omega_o$ is called a decade, and if the logarithmic base is 10, the graph-paper "pattern" repeats itself over successive decades.

Next, consider the contributions to gain and phase by terms making up a typical transfer function.

Example 1

$$Y(j\omega) = \frac{1}{1 + j\omega T}$$

Here

$$\left.\begin{aligned} A(\omega) &= -10 \log (1 + \omega^2 T^2) \\ \psi(\omega) &= -\tan^{-1}(\omega T) \end{aligned}\right\} \qquad (6)$$

These equations take the form shown by the solid curve in Figs. 2 and 3. It will be seen that if they are approximated by the straight-line segments shown dashed, however, the errors involved are only slight. The gain approximations are continuations of the low and high-frequency asymptotes which join at the so-called break frequency $\omega = 1/T$. ($A \approx 20 \log \omega T$ for $\omega T \geqq 1$; $A \approx 20 \log 1 = 0$ for $\omega T \leqq 1$.) The only reason for the choice of phase approximation is that it is the straight line which involves the most reasonable errors.

These straight-line approximations can be used with a fair degree of success at an initial design stage but, of course, necessary corrections must be made when an accurate plot is required at a later stage. The corrections which must be made can be seen in Figs. 2 and 3. It will be seen that the greatest error involved in using the asymptotic gain approximation is 3 db occurring at the break frequency, while the greatest error in phase is about 5 deg.

Note that the gain asymptote has a slope of -20 db per decade while the phase angle tends to -90 deg for high frequencies. For a term $1 + j\omega T$ appearing in the numerator (i.e., a phase lead term) the gain and phase diagrams are numerically equal to the case just considered, but they are reversed in sign. Thus the high-frequency gain asymptote has a slope of $+20$ db per decade, while the phase angle tends to $+90$ deg.

Example 2

$$Y(j\omega) = \frac{1}{1 + j\omega T_1 - \omega^2 T_2^2}$$

It has been shown that quadratic lag terms can conveniently be described in terms of a characteristic frequency ω_n and a damping ratio ζ. Here $\omega_n = 1/T_2$, $\zeta = T_1/2T_2$. The asymptotic behavior of $Y(j\omega)$ in this case is

$\omega T_2 \leqq 1$ $\quad A(\omega) \approx 0$ db

$\quad\quad\quad

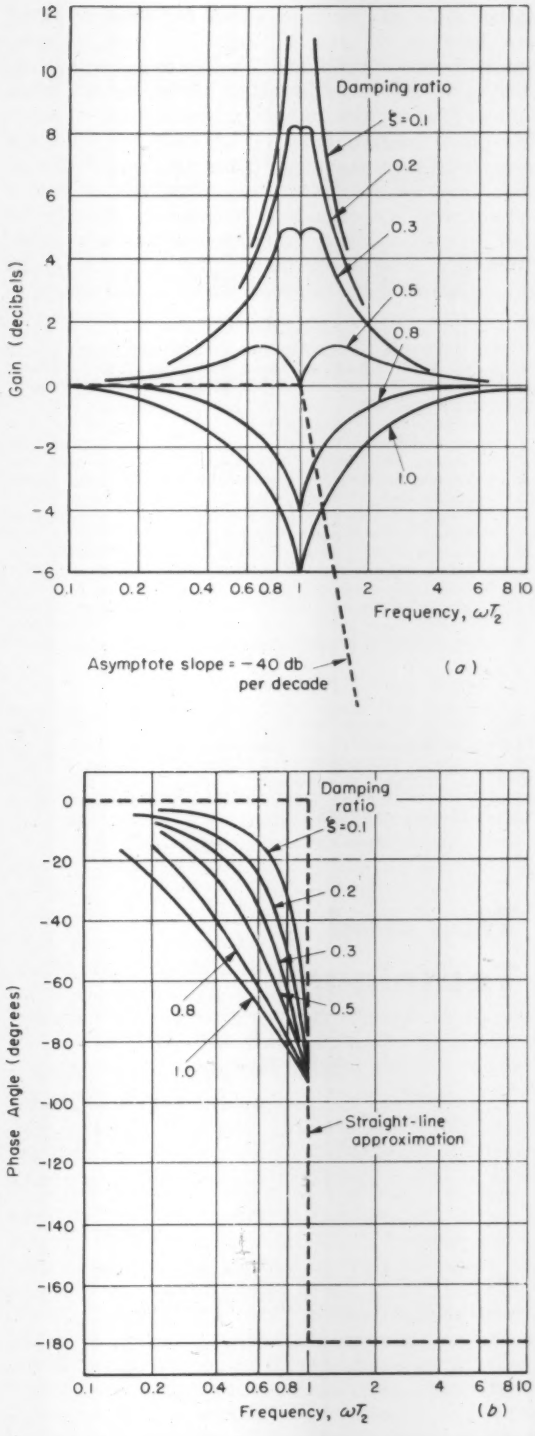


Fig. 4—Dashed curves give straight-line approximations to gain and phase characteristics for a quadratic lag term. In this case the corrections which have to be applied will depend on the damping ratio ζ. Phase corrections, at *b*, form a symmetrical pattern about $\omega T_2 = 1$, only half of which is shown. For frequencies above this value the corrections to be added to the approximate curve are positive.

are plotted for various values of ζ in Fig. 4 (solid curves).

Example 3

$$Y(j\omega) = \frac{K}{(j\omega)^r}$$

This term lumps together as a nondimensional factor the frequency characteristics of all the integrations in the forward path and the loop scalar gain constant K. The gain characteristics are the straight lines shown in Fig. 5*a* (no need to approximate here). Because the gain constant K very often has to be selected by consideration of the complete system, it is very convenient to split the gain curve into two separate components as shown in Fig. 5*b*. The scalar gain K is now associated with the line parallel to the ω-axis. The phase angle is constant at $-r \times 90$ deg for all frequencies.

Application: Now this technique can be applied to a typical servo. Let the loop response function of the system be

$$Y_o(j\omega) = \frac{K}{j\omega(1 + 0.2\,j\omega)(1 + 0.6\,j\omega - 0.25\,\omega^2)} \qquad (7)$$

The separate components of the various factors are shown by the solid curves of Fig. 6, while the resultant gain and phase curves, found by adding

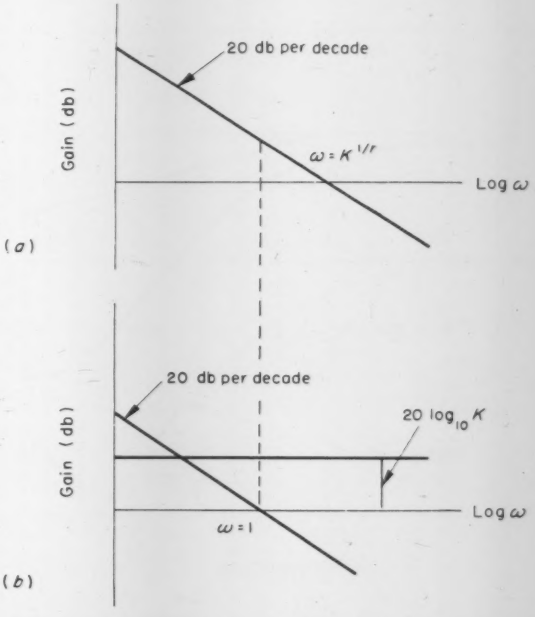


Fig. 5—At *a*, gain characteristic for $K/(j\omega)^r$. Curve can be broken down into two components as shown at *b*. In this case the phase angle is constant at $-r \times 90$ deg.

the components, are shown dashed. The gain curve is plotted for $K = 0.6$.

It will be realized that the value of K merely lifts the gain curve by the corresponding number of decibels, and this affords a particularly convenient way of determining a suitable value of K if the gain and phase margin criteria are used. These quantities are defined in Fig. 6. Note that the phase margin is exactly that defined in Reference 4, but the gain margin definition here is rather different. Suitable values for phase margins are between 30 and 45 deg. For gain margin, values between 6 db and 12 db are recommended with a mean value probably about right. These figures give a guide to good relative stability, since the phase margin must be at least greater than zero to insure stability. Thus the initial design procedure is to plot only frequency-sensitive asymptotes (i.e., ignoring K) and to lift up the gain curve until the stability margins are right. Then the amount the gain curve is shifted gives the value of K in decibels.

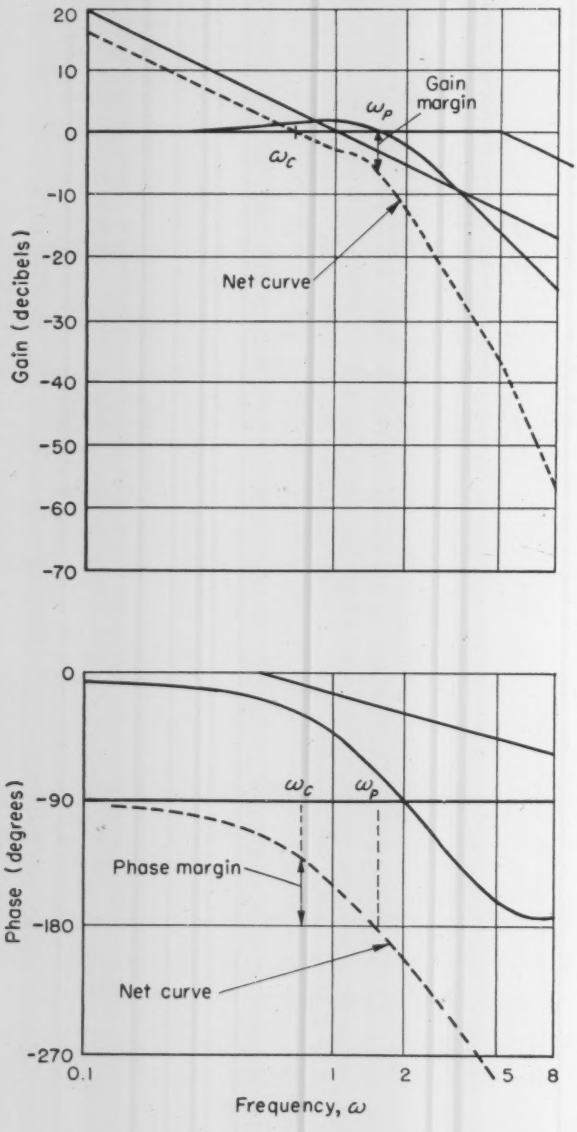


Fig. 6—Gain and phase of component factors of a typical loop transfer function. These components can be added to give the net characteristics of the loop response function. Gain and phase margins are simply defined by means of these diagrams.

REFERENCES

This article is the fourteenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" .. July 26, 1956
4. "Evaluating Servo System Performance—Part 2" .. Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957
10. "Hydraulic Servos—Part 2" ..... Mar. 7, 1957
11. "Hydraulic Servos—Part 3" ..... Mar. 21, 1957
12. "Improving Servo System Performance—Part 1" .. May 30, 1957
13. "Improving Servo System Performance—Part 2" .. June 13, 1957

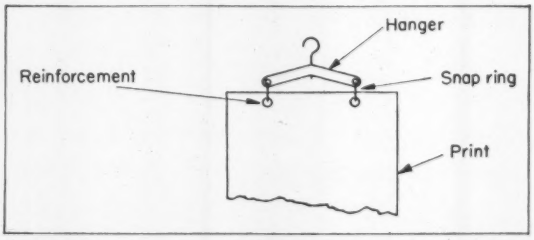
REPRINTS

Articles listed above by J. M. Nightingale are now available in reprint form. Articles 1 to 5 are contained in Volume 1 (32 pages) and articles 6 to 11 in Volume 2 (32 pages) of "Hydraulic Servo Fundamentals." The volumes are available at $1.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Tips and Techniques

Print Hanger

A quick, easy and inexpensive method of storing large blueprints, without folding, is to hang them vertically from wooden coat hangers. An ordinary coat hanger is shortened on each end to an overall



length of 9½ in. Two holes are then drilled in the hanger, 8½ in. apart. Two holes are punched in one end of the prints with a standard 8½-in.-space paper punch. The holes should be furnished with gummed reinforcements. Snap rings are used to fasten a group of prints to each hanger.—J. C. GARNER, *Raytheon Mfg. Co., Wayland, Mass.*

General equations for finding

Cam Curves and Cutter Pitch Curves

By H. H. Pan
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DESIGNING a plate cam with a roller-contact type follower usually does not end after successfully obtaining the desired pitch curve. Finding the cam curve which defines the actual cam surface is also required in some cases, so that from that curve a master cam can be made, Fig. 1. In other cases, if the cam is cut with a cutter size different from that of the follower-roller, the trace of the cutter path—the cutter pitch curve—should also be known in order to cut the right profile of the cam.

For cams running at low speeds this does not constitute a problem since both the cam curve and the cutter path can very easily be determined graphically. For example, to find the cam curve, one needs only to draw a series of circles having their radii equal to the radius of the follower-roller and with their centers lying on the pitch curve. The cam curve is nothing but the envelope of these circles. However, in the design of high-speed cams, the graphical method can not be used because of its relative inaccuracy. In such cases, deviation from the desired curve will result in poor dynamic performance of the cam. Therefore, the cam curve or the cutter path should be determined analytically. General equations for these curves are derived in the following manner in polar co-ordinates to facilitate such determination. These equations can be used to find the cam curve or cutter path when the pitch curve is given. A later section discusses how to obtain pitch curves.

Cam Curve: In Fig. 2 varying position-vector $\mathbf{R}_1$ defines the pitch curve, and varying position-vector $\mathbf{R}$ defines the cam curve. Also $\mathbf{N}_1$ denotes the unit normal vector to the pitch curve, $\mathbf{N}$ denotes the unit normal vector to the cam curve,

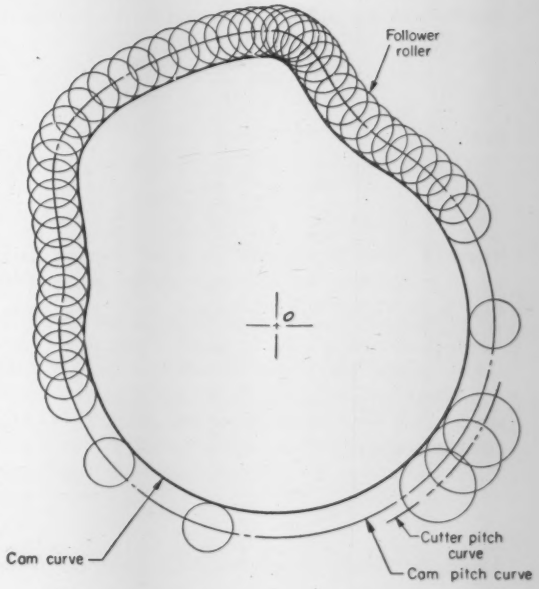


Fig. 1—Cam and cutter curves of a typical cam.

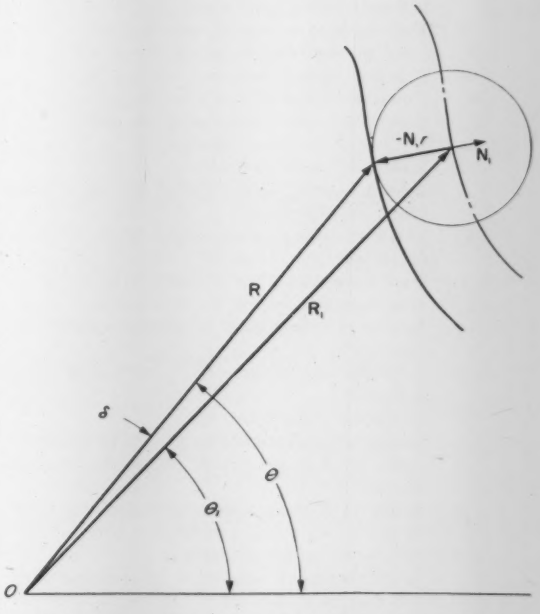


Fig. 2—Portion of cam and pitch curves showing nomenclature employed in analysis.

and r denotes the radius of the follower-roller. Then, adding vectorially,

$$\mathbf{R}_1 = \mathbf{R} + (\mp \mathbf{N}r) \qquad (1)$$

The minus sign is chosen when the center of curvature and center of cam rotation, point O, are at the same side of the curve.

If $\mathbf{R}_1$ and $\mathbf{R}$ are both expressed in the function of respective curve lengths s_1 and s from some fixed points on the curves, differentiation of both members of Equation 1 with respect to s gives

$$\frac{d\mathbf{R}_1}{ds_1}\frac{ds_1}{ds} = \frac{d\mathbf{R}}{ds} \mp r\frac{d\mathbf{N}}{ds}$$

But

$$\frac{d\mathbf{R}_1}{ds_1} = \mathbf{T}_1, \frac{d\mathbf{R}}{ds} = \mathbf{T}$$

where $\mathbf{T}_1$ and $\mathbf{T}$ are unit tangent vectors to the pitch curve and to the cam curve respectively, Fig. 3. By Frenet's formula

$$\frac{d\mathbf{N}}{ds} = -\kappa\mathbf{T}$$

where κ is the curvature of the pitch curve. Substituting, then,

$$\mathbf{T}_1\frac{ds_1}{ds} = (1 \pm \kappa r)\mathbf{T}$$

As ds_1/ds and $(1 \pm \kappa r)$ are both scalar quantities,

Nomenclature

- a = Offset of reciprocating follower
- l = Distance between centers of cam shaft and follower swing-arm pivot
- $\mathbf{N}$ = Unit normal vector to cam curve
- $\mathbf{N}_1$ = Unit normal vector to pitch curve
- $\mathbf{R}$ = Position-vector defining cam curve
- $\mathbf{R}_1$ = Position-vector defining pitch curve
- R_1' = Radius of base circle of pitch curve
- R_f = Radius of follower swing-arm
- r = Radius of follower-roller
- s = Distance along cam curve of $\mathbf{R}$ from a fixed point on the curve
- s_1 = Distance along pitch curve of $\mathbf{R}_1$ from a fixed point on the curve
- $\mathbf{T}$ = Unit tangent vector to cam curve
- $\mathbf{T}_1$ = Unit tangent vector to pitch curve
- y = Linear displacement of reciprocating follower
- β = Angular displacement of swinging type follower
- δ = Angle between $\mathbf{R}$ and $\mathbf{R}_1$
- ε = Angle subtended on cam center by displacement of follower-roller center (correction angle)
- θ = Angle of $\mathbf{R}$ from a reference line
- θ_1 = Angle of $\mathbf{R}_1$ from a reference line
- κ = Curvature of pitch curve
- τ = Angle between centerline of reciprocating follower and cam radius through reference point
- ω = Angle rotated by cam

since two vectors are equal, they should have the same direction, and since both $\mathbf{T}_1$ and $\mathbf{T}$ are unit vectors by definition, so $\mathbf{T}_1$ must be equal to $\mathbf{T}$. Therefore, these two curves are parallel. Hence,

$$\mathbf{N}_1 = \mathbf{N}$$

and

$$\mathbf{R} = \mathbf{R}_1 \pm \mathbf{N}_1 r \qquad (2)$$

This is the vector expression for the cam curve expressed in terms of the pitch curve.

Dot products of both members of Equation 2 into themselves give

$$\mathbf{R}^2 = \mathbf{R}_1^2 + r^2 - 2\mathbf{R}_1 r\cos(\mathbf{N}_1, \mathbf{R}_1) \qquad (3)$$

But

$$\cos(\mathbf{N}_1, \mathbf{R}_1) = \sin(\mathbf{T}_1, \mathbf{R}_1)$$

Next

$$\sin(\mathbf{T}_1, \mathbf{R}_1) \approx \frac{\mathbf{R}_1\,\Delta\theta_1}{\Delta s_1}$$

and

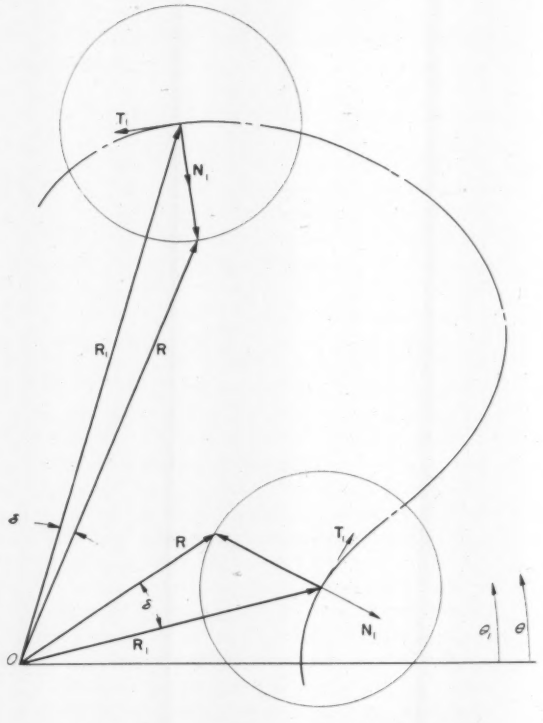


Fig. 3—Portion of pitch curve showing that δ may be either plus or minus according to whether the curve bends away from the center of cam rotation, O, or toward it.

$$\Delta s \approx \sqrt{(\mathbf{R}_1 + \Delta\mathbf{R}_1)^2(\Delta\theta)^2 + (\Delta\mathbf{R}_1)^2}$$

Then, causing $\Delta\theta$ to approach zero gives an exact expression for sin $(\mathbf{T}_1, \mathbf{R}_1)$ as the limit,

$$\sin(\mathbf{T}_1, \mathbf{R}_1) = \frac{\mathbf{R}_1\, d\,\theta_1}{\sqrt{(\mathbf{R}_1 d\,\theta_1)^2 + (d\mathbf{R}_1)^2}} = \frac{1}{\sqrt{1 + \left(\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}\right)^2}}$$

Substitution into Equation 3 yields

$$\mathbf{R}^2 = \mathbf{R}_1^2 + r^2 - \frac{2\mathbf{R}_1 r}{\sqrt{1 + \left(\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}\right)^2}} \qquad (4)$$

The direction of vector **R**, Figs. 2 and 3, is

$$\theta = \theta_1 + \delta$$

As shown in Fig. 3, δ is a positive quantity when the curve bends away from point O and is a negative quantity when the curve bends toward point O.

By sine law,

$$r \sin(\mathbf{N}_1, \mathbf{R}_1) = \pm\, \mathbf{R} \sin\delta$$

But

$$\sin(\mathbf{N}_1, \mathbf{R}_1) = \pm \cos(\mathbf{T}_1, \mathbf{R}_1)$$

Therefore

$$\mathbf{R} \sin\delta = \frac{r\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}}{\sqrt{1 + \left(\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}\right)^2}}$$

Hence, in polar co-ordinates the equations for cam curve are

$$\mathbf{R} = \sqrt{\mathbf{R}_1^2 + r^2 - \frac{2\mathbf{R}_1 r}{\sqrt{1 + \left(\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}\right)^2}}} \qquad (5a)$$

$$\theta = \theta_1 + \sin^{-1}\left[\frac{r\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}}{\mathbf{R}\sqrt{1 + \left(\frac{d\mathbf{R}_1}{\mathbf{R}_1 d\theta_1}\right)^2}}\right] \qquad (5b)$$

It is to be noticed here than when the curve bends away from point O, $d\mathbf{R}_1/\mathbf{R}_1 d\theta_1$ is positive, which makes δ positive. When the curve bends toward point O, $d\mathbf{R}_1/\mathbf{R}_1 d\theta_1$ is negative, making δ negative. This agrees with the fact that vector **R** leads vector $\mathbf{R}_1$ when the curve bends away from point O and falls behind vector $\mathbf{R}_1$ when the curve bends toward point O.

Cutter Path: Equations 5*a* and *b* could also be used to find the cutter path if the algebraic difference between the radius of the follower-roller

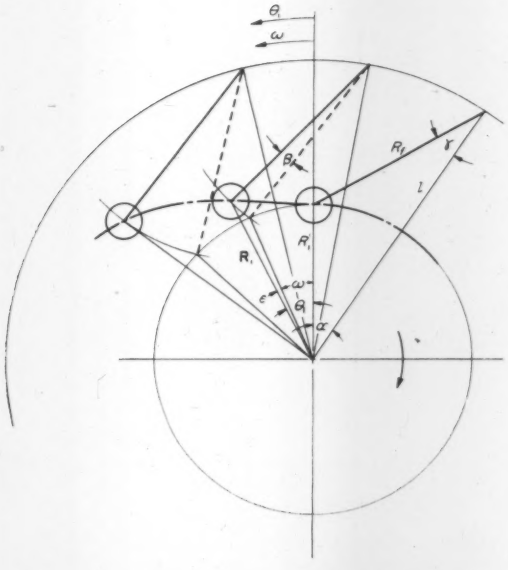


Fig. 4—Geometry for obtaining pitch curve of cam for a swinging type follower.

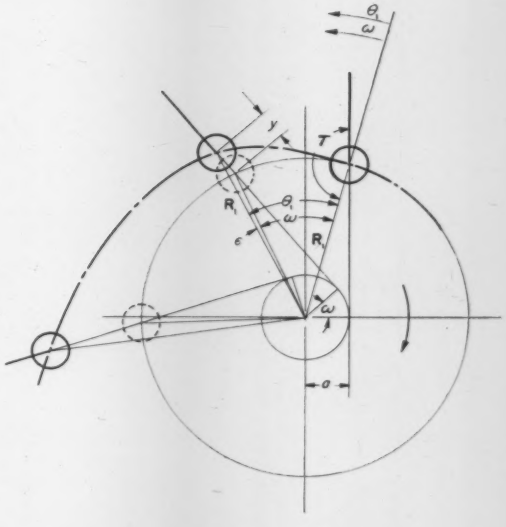


Fig. 5—Geometry for obtaining pitch curve of cam for a reciprocating follower.

and the radius of the cutter is substituted for r. Radius of the cutter should be subtracted from the radius of the follower-roller to get this difference. This difference is positive when the cutter is smaller than the follower-roller and is negative when the cutter is larger than the follower-roller. Care must be taken not to use a cutter so large as to undercut the cam profile.

Obtaining Pitch Curve: Equations 5*a* and *b* are derived for use when the pitch curve is given. If the pitch curve is not given, it can be obtained to meet the desired time-motion relationship of the follower in the following manner.

The motion is usually denoted by the amount of displacement of the follower from a certain chosen reference point or reference line. In the case of a swinging type follower, this displacement will be the angular displacement of the follower arm and in the case of a reciprocating type follower this displacement will be the linear displacement of the follower along the line of motion. Time may be expressed in terms of the cam angle rotated, so the prescribed time-motion relationship of the follower may be expressed in displacement as a certain specified function of the cam angle rotated. It is convenient to place the reference point at the location where the follower starts to rise from the base circle of the pitch curve.

In Figs. 4 and 5, β and y denote the displacement, and ω denotes cam angle rotated. Let R_f denote the radius of the follower swing-arm and R_1' denote the radius of the base circle of the pitch curve. Center-to-center distance between the cam shaft and the swing-arm pivot is l, and τ is the angle between the centerline of the follower and the cam radius passing through the reference point. To make the following equations still hold true when the offset is to the left, τ will be measured in the direction as indicated. From the sine law and the cosine law the following relationships are easily established:

For a swinging type follower,

$$\mathbf{R}_1 = R_f^2 + l^2 - 2R_f\, l \cos(\beta + \gamma) \qquad (6a)$$

$$\mathbf{R}_1 \sin(\alpha + \varepsilon) = R_f \sin(\beta + \gamma) \qquad (6b)$$

in which

$$\gamma = 2 \sin^{-1} \sqrt{\frac{(s - R_f)(s - l)}{R_f l}}$$

$$\alpha = 2 \sin^{-1} \sqrt{\frac{(s - R_1')(s - l)}{R_1' l}}$$

where

$$s = \frac{l + R_1' + R_f}{2}$$

and ε is the angle subtended on the cam center by displacement of the follower-roller center.

For a reciprocating type follower,

$$\mathbf{R}_1 = \sqrt{R_1'^2 + y^2 - 2yR_1' \cos\tau} \qquad (7a)$$

$$\mathbf{R}_1 \sin\varepsilon = y \sin\tau \qquad (7b)$$

in which τ is 180 deg $- \sin^{-1}(a/R_1')$ where a is the amount of offset.

Hence, to find the pitch curve, one may use Equation 6*a* or 7*a* to find $\mathbf{R}_1$ and substitute it into Equation 6*b* or 7*b* to evaluate the correction angle ε. The pitch curve is then defined by the polar co-ordinates $(\mathbf{R}_1, \theta_1)$ in which $\theta_1 = \omega + \varepsilon$. Which pair of the equations should be used depends on whether a swinging type or a reciprocating type follower is under consideration.

In the second pair of equations when $\tau = 180$ deg and $\cos\tau = -1$, Equation 7*a* reduces to $\mathbf{R}_1 = R_1' + y$. As sin 180 deg $= 0$, from Equation 7*b* the correction angle ε equals zero. This, of course, is true in the case of a radial-arrangement follower.

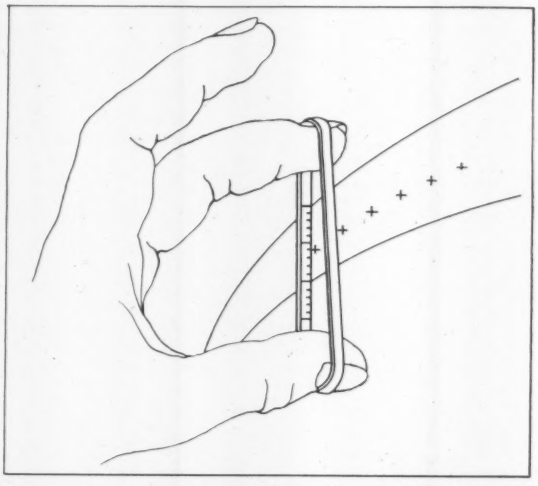
Usually it is convenient to express the pitch curve only in tabulated form. In that case, numerical differentiation may be applied to obtain $d\mathbf{R}_1/d\theta_1$ for use in Equations 5*a* and *b*.*

*W. E. Milne—*Numerical Calculus*, Princeton University Press, Princeton, N. J., 1949.

Tips and Techniques

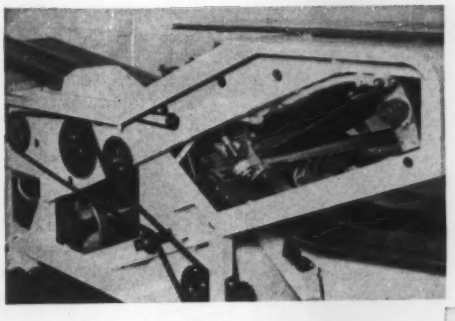
Stretchable Scale

For interpolating points between curved lines that are various distances apart, a common rubber band is of great value. On the inside of the band, an



appropriate scale is inked. The band is then stretched until a convenient number of graduations lies between the selected points on the curved lines. New curves may be plotted, intermediate points located, and value of given points determined.—ALFRED TEPLITZ, *Pittsburgh, Pa.*

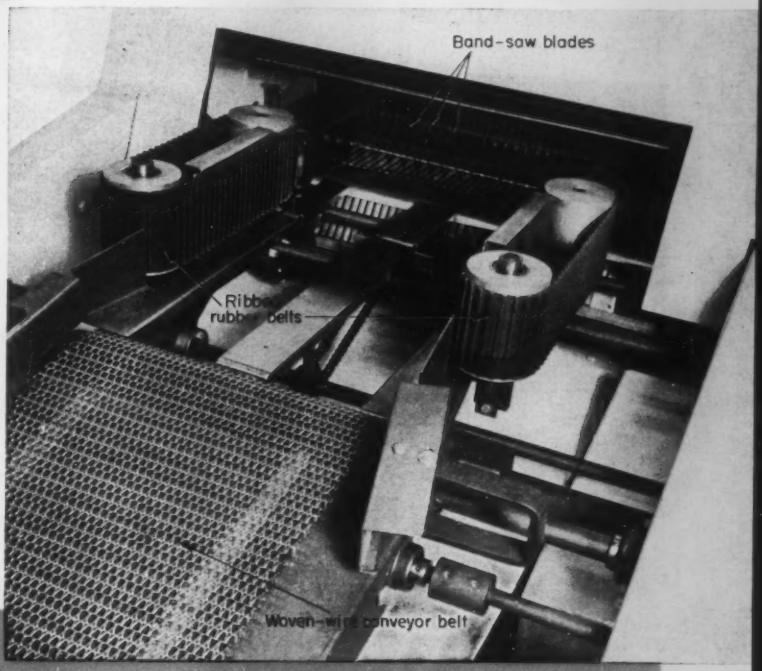
Resilient-Ring "Springs" Permit Adjustable Thickness Control

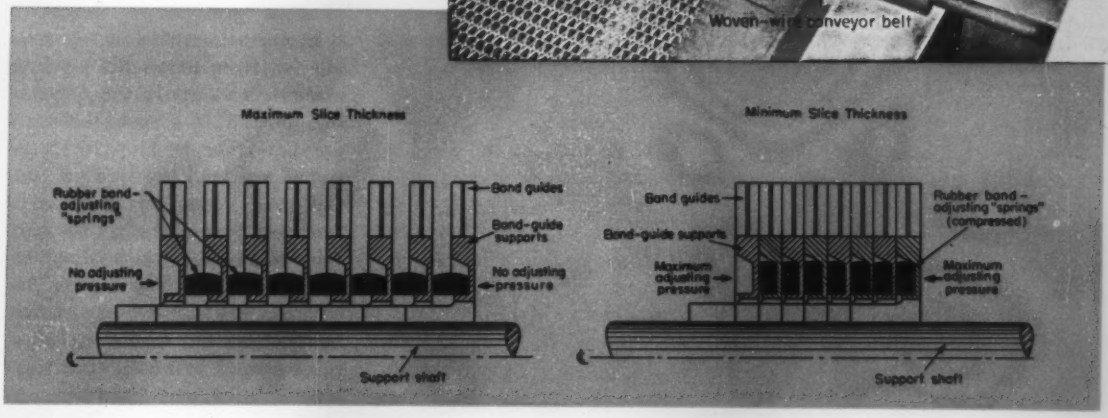


A simplified method of spacing of band-saw blades in a high-speed bread slicer is accomplished through the novel application of a series of rubber band-adjusting "springs." Manufactured by the National Bakery Div., Package Machinery Co., the machine is designed to slice 75 loaves per minute. A total of 21 band type saw blades provide, in effect, 42 slicing elements that are equally spaced.

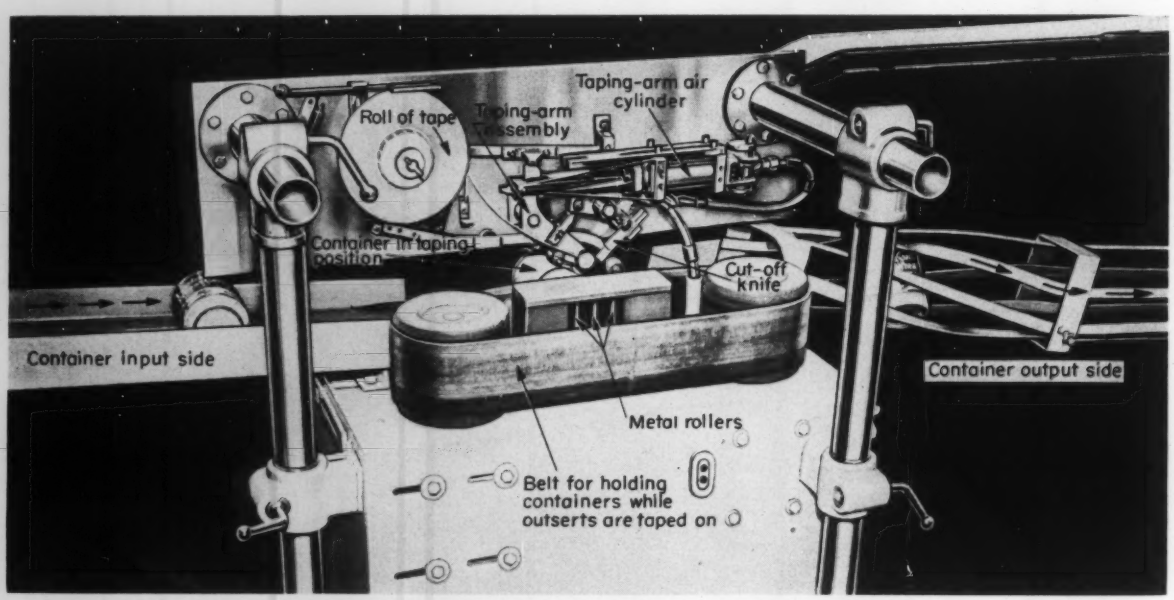
Input conveying of bread into the slicing section is provided by a flexible woven-wire belt. Unsliced bread is moved continuously from the end of the wire belt in between two ribbed, flat rubber belts that slide the loaves by gripping their ends.

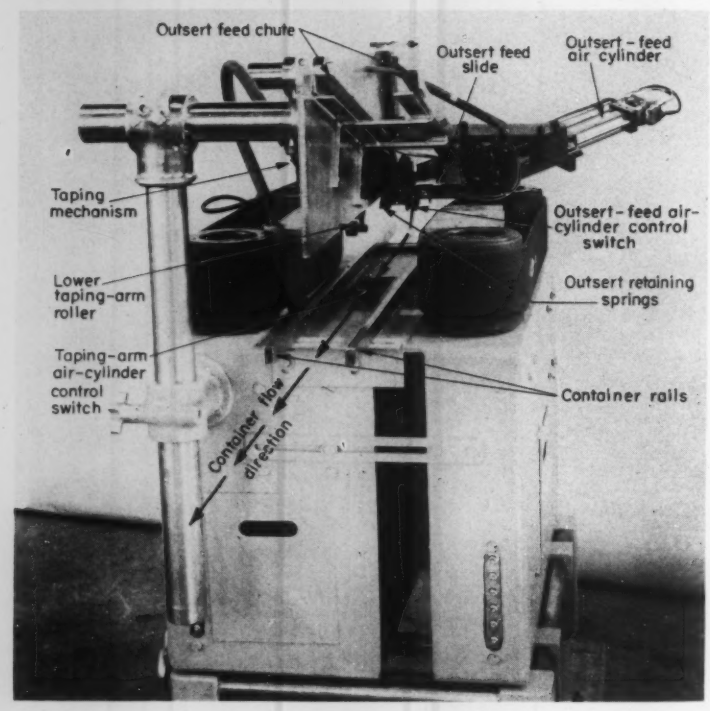
Spacing distance between band saw blades is controlled by the adjusting pressure applied to a series of rubber, ring-shaped spring elements positioned between the band guide supports. Slice thickness can be varied between 5/16 and 9/16-in.





High-Speed Outsert-Taping Mechanism Is Electrically Controlled

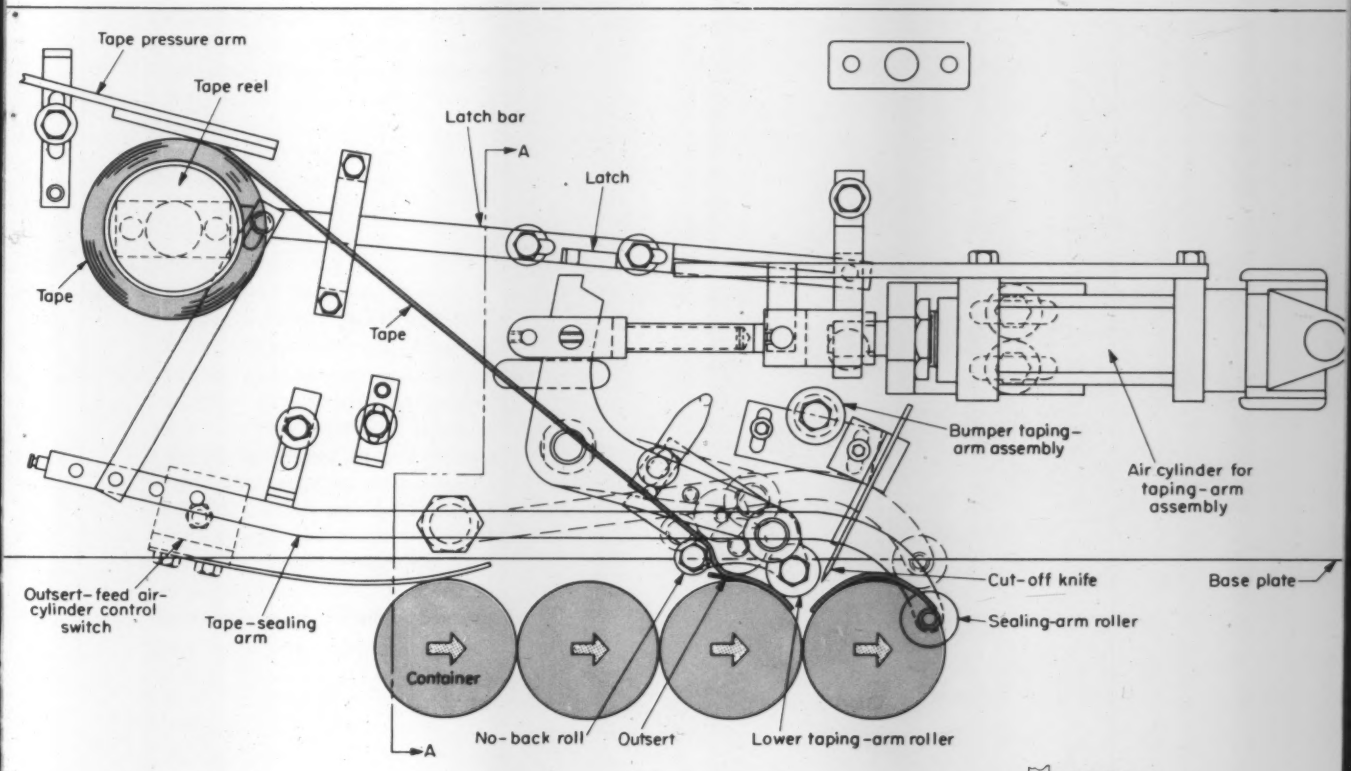




Accurate attachment of outsert leaflets to the outside of cylindrical containers at speeds as high as 220 per minute is done automatically by the Pfaudler Outsert Applicator. Containers having dimensions ranging from $2\frac{5}{8}$ to $7\frac{1}{4}$ in. in length and $1\frac{1}{4}$ to $6\frac{1}{2}$ in. in diameter can be handled.

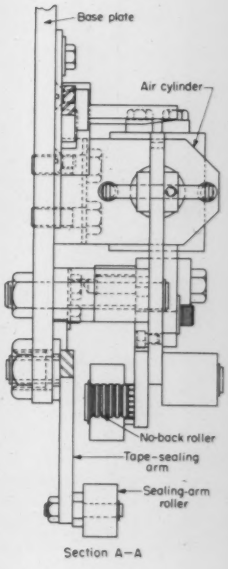
In operation, after a free-rolling container leaves the labeling machine and enters the outserting unit, it is gripped between parallel belts to stop its rotational motion. Position of the container when it is gripped is preset to face-up only that portion of the container to which the outsert is to be taped. The first outsert leaflet is positioned by the manual operation of a reset switch which in turn controls the outsert feed mecha-

and Pneumatically Operated

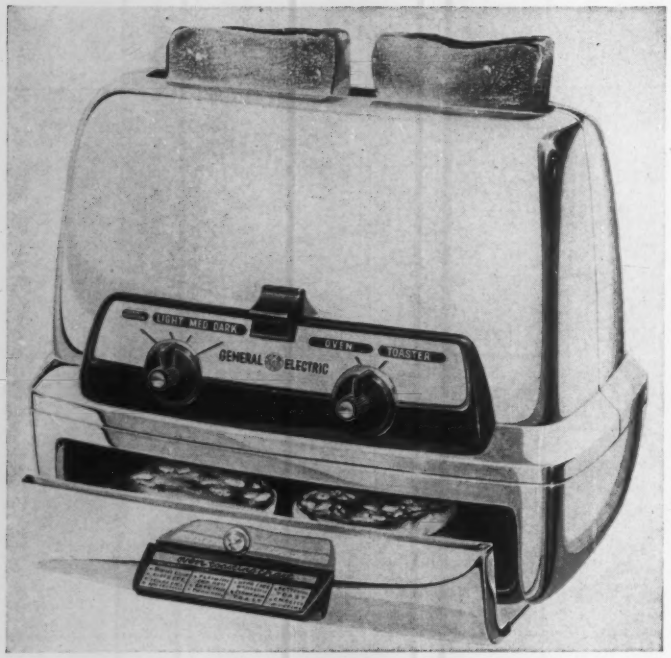


nism in the machine.

As the holding belts carry the container farther along, the outsert is pulled from retaining springs. At the same time the lower taping-arm roller has started adhesion of the free end of the tape on the forefront of the container. As forward motion of the container continues, another precision snap-action switch located between the rails under the container operates the taping-arm assembly air cylinder. This action pivots the taping-arm assembly, raising the taut tape against the cut-off knife and cutting it off. Succeeding outserts are fed and positioned automatically by the outserted container tripping a precision snap-action switch located to feed a leaflet under the taping arm and tape while both are raised in the cut-off position. The tape is retained between the no-back wheel and the rubber roll. Continued forward movement of container causes tape-sealing-arm roller to press down the trailing end of the fastening tape. Meanwhile the free end of the tape is pressed against the succeeding container.



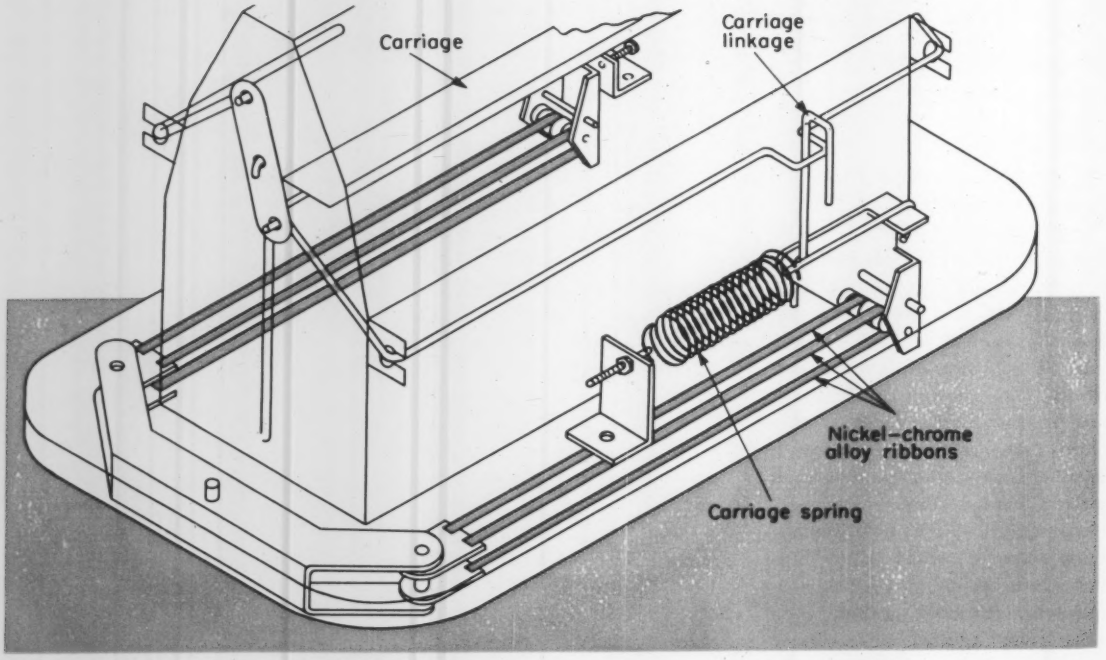
Expansible Metal Ribbons



A novel design arrangement of spring, linkage and lever members is employed in the carriage-lifting mechanism in G-E's Toast-R-Oven, which is a combination toaster-and-oven unit.

Carriage-lifting force is provided by the carriage spring, which is fastened to the top of the linkage actuation lever. Angular position of this lever is controlled by the length of nickel-chrome alloy ribbons, which are fastened at the bottom of the lever.

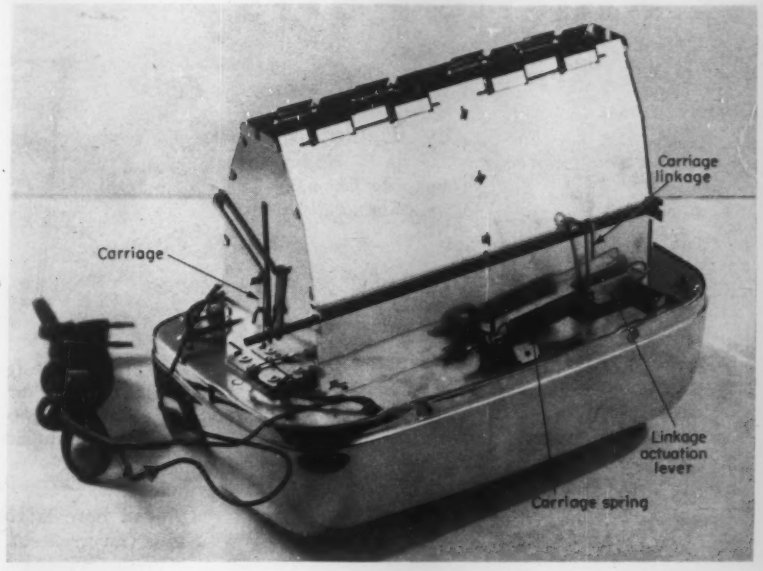
In operation, bread is placed in the slot and a pushbutton is pressed which unlatches and

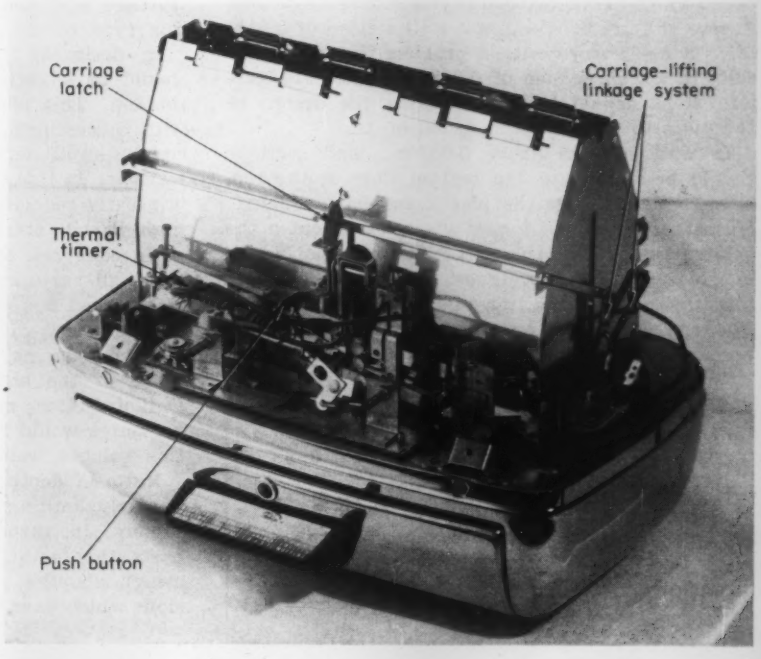


Control Spring Drive

drops the carriage and energizes the toasting heater. When the toasting period is completed, a timer opens the toasting-heater contacts and closes a set of contacts that connects electric power to heat the drive ribbons. The ribbons expand quickly permitting the carriage spring to contract and pull the carriage back to the upper position where the drive - ribbon contacts open and the carriage relatches in place. The metal drive ribbons cool and contract permitting the carriage spring to extend again.

As reported by Paul O. Rawson, designer-in-charge, and W. A. Schmall, project development engineer, special care was taken in the design of the linkages to provide variable force multiplication, depending on carriage elevation. This design feature permits stress in the nickel-chrome alloy ribbons to approximate the yield - strength versus temperature curve of the material, which means that the ribbons are stressed less when heated.





Photos, courtesy General Electric Review

Design of Thin-Wall Plastic Parts

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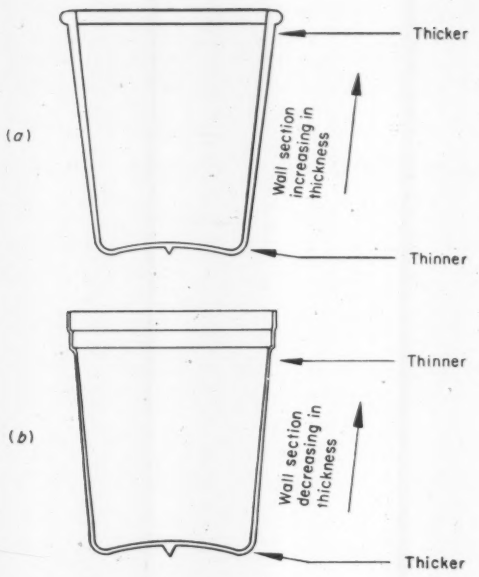

Fig. 1—Design of thin-wall parts and containers: *a*, above 0.035-in. wall section in general-purpose styrene; *b*, below 0.035-in. in high-impact styrene.

THE CONCEPT of molding thin plastic sections, and even the concept of what comprises a thin section, has changed considerably in recent times.

Several years ago, a styrene wall section of 0.048-in. was considered thin. Today containers and parts of 0.014-in. in thickness are not uncommon. The necessity of molding these thin sections in styrene plastic has emphasized the importance of proper design for optimum performance of the finished part.

Actual configuration of the thin wall is of prime importance. One of the greatest problems in molding the thin-wall part is core shift. Core shift is a sidewise movement of the core which is induced by the high (20,000 psi) molding pressures. A core shift of 0.003-in. in a wall section of 0.014-in. is a much more critical problem than a similar shift in a wall section of 0.048-in. Therefore, certain steps should be taken during the design of the piece to minimize this problem.

In wall sections above 0.035-in., wall sections should be thinner at the bottom than at the top, Fig. 1. This allows the plastic material which is hottest and has the lowest viscosity to enter the thinnest section of the part. The material which is coolest and has the highest viscosity then moves into the enlarged section and into the edge rim. The rim should be approximately 1½ times the preceding wall section. The principle to be employed here is that the coolest material will flow into the greatest area. This, with general-purpose styrene, will lessen the tendency toward crazing, for general-purpose styrene definitely tends to craze if cool material is packed into a thin section.

In molding wall sections of 0.035-in. and below, general-purpose styrene material should not be used. High orientation of the styrene molecules causes a drop in strength properties. High-impact styrenes now available are adequately suited for this type of molding, however.

In designing these thin-wall parts, the wall should be slightly thicker at the bottom than at the top. This allows the plastic material to flow with concentricity up the cavity, being restrained equally on all sides by the slightly decreasing wall sections. In this case, the tendency toward crazing is greatly reduced by the higher elongation of the high-impact styrene materials.

No edge rim of any magnitude is employed in thin-wall parts and containers below 0.035-in. Instead, most lips are folded over, or a step arrangement is used. It should be noted that the constantly reducing wall thickness is necessary because of the higher pressure required for thin-wall injection molding. Sudden, high injection pressures would force the core over in the mold if this balance were not provided.

Ratio of depth to diameter has not been a particularly limiting factor in molding thin-wall containers. In vacuum forming of sheet into such parts, this factor becomes an important part of the design planning. However, Table 1 shows dimensions which have been produced successfully in thin wall sections by injection molding.

Table 1—Dimensions of Cylindrical Cups

Wall Section (in.)	Depth (in.)	Diameter (in.)
0.014	3	2
0.022	3⅝	2 13/16
0.018	3⅝	2⅛

Mechanics of Vehicles-4

Stability on a Curve

- centrifugal forces
- force distribution
- sliding and tipping

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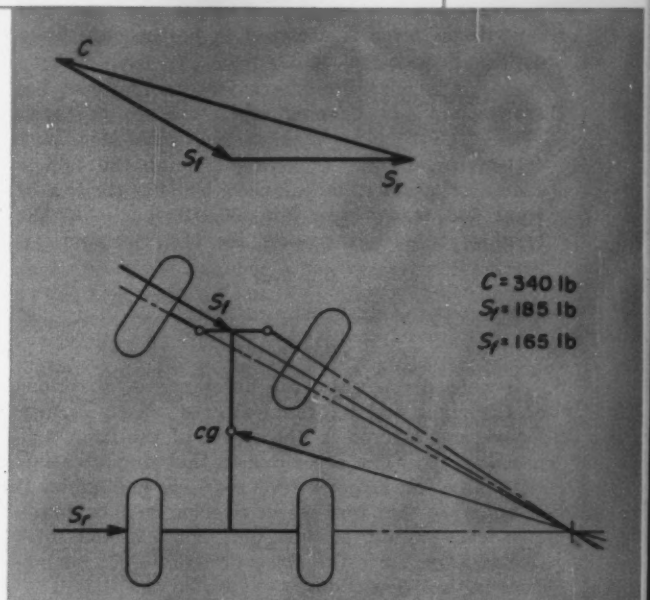

Fig. 30—Side-thrust distribution to front and rear wheels on a vehicle negotiating a curve. Only centrifugal force is assumed to act in this simplified case (rolling resistance is neglected).

DIRECTIONAL stability and the side-skidding characteristics of a vehicle negotiating a curve depend upon the balance of dynamic side forces. The nature of these forces, their distribution, and their effects on vehicle stability are examined in the following sections of this article.

Dynamic Side Forces

In curvilinear motion, centrifugal force C (acting ideally at the vehicle center of gravity) is held in equilibrium by the sum of the side-force reactions on all wheels, or

$$C = mr_c\,\omega^2 = \frac{Wv^2}{gr_c} = \sum S \qquad (31)$$

Here, v is the translatory speed of a vehicle of mass m, ω is angular velocity, r_c is radius of curvature and ΣS is the sum of the side-force reactions.

When a vehicle enters a curve, changing its motion from rectilinear to curvilinear, the side-force reactions impose a rate change of angular momentum $I\alpha$. For a vehicle with polar moment of inertia I (around the vertical axis), wheelbase L, road-adhesion coefficient μ and angular acceleration α, the relation between side forces and rate of change of angular momentum is

$$\sum S = \frac{I\alpha}{L} \leq W\mu \qquad (32)$$

Obviously, the vehicle with small moment of inertia will exhibit fast directional response. Large inertia moments, while slowing down directional response, decrease sensitivity to secondary disturbances. Such a vehicle would tend to maintain its original direction of motion.

Weight distribution (fore and aft) is a determining factor for vehicle polar inertia. Heavy components are preferably located close to the center of gravity for minimum inertia moments. Intended use of the vehicle, since it dictates the necessary compromise between directional response and directional stability, decides the final solution to the weight-distribution problem.

Force Distribution: Equation 31 gave the side force required to balance the centrifugal force on the vehicle. Traction and braking forces acting on the steered wheels, as well as other motion-affecting forces acting ideally at the cg of the vehicle, all produce side-force components which may add to or subtract from the centrifugal force. The side-thrust reaction of the tires must balance the resultant of all these factors.

From a directional-stability standpoint, distribu-

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tion of side forces to the wheels is important. Limits of safe maneuverability are determined by the wheel which first starts to slide. Vectorial analysis by graphical techniques offers a method of determining side-force distribution. The method is demonstrated in sections that follow for a vehicle weighing 4000 lb (evenly distributed on front and rear axles) negotiating a curve of radius of $r_c = 20$ ft at a speed of 5 mph (7.33 ft per sec).

VEHICLE AT CONSTANT SPEED: In this example, rolling resistance of the vehicle is neglected and centrifugal force is assumed to be the only force acting. From Equation 31,

$$C = \frac{4000(7.33)^2}{(32.2)(20)} = 340 \text{ lb} \qquad (33)$$

Centrifugal force C, acting through the vehicle center of gravity, is balanced by side thrusts of front and rear wheels, Fig. 30. Obviously, as the turning radius r_c increases, the vectorial sum

$$C = S_f + S_r$$

approaches the algebraic sum

$$C = S_f + S_r$$

In this simple case, the difference in directions of the right and left-hand steered wheels is neglected, and a force on the center of the front axle is calculated. The error due to this simplification, especially for larger curve radii, is negligible. It is apparent that rear-wheel steering in this simplified case would produce an identical side-force distribution, since the drive direction does not appear in the calculations.

VEHICLE IN ACCELERATED MOTION: In this case, the following forces act on the vehicle: centrifugal force $C = 340$ lb (same as in simplified example); total rolling resistance $R_r = Wf = (4000)(0.02) = 80$ lb. Assuming an acceleration a of 3 fps^2, the inertia force is $R_i = (W/g)a = (4000/32)3 = 375$ lb.

Grade and air resistances are neglected here. The graphical method of calculation is demon-

Nomenclature

C = Centrifugal force, lb
H = Height of center of gravity, ft
I = Polar moment of inertia of vehicle around vertical axis, ft-lb-sec^2
L = Wheelbase, ft
m = Mass, lb-sec^2 per ft
n = Distance determining tipping stability, ft
P = Tractive force, lb
R_i = Inertia resistance, lb
R_r = Rolling resistance, lb
r_c = Radius of curvature, ft
S = Side-force reaction of wheels, lb
V = Speed, mph
v = Speed, ft per sec
W = Vehicle weight, lb
α = Angular acceleration, rad per sec^2
β = Superelevation angle, deg
μ_s = Coefficient of sliding friction
ϕ = Frictional angle, rad
ω = Angular speed, rad per sec

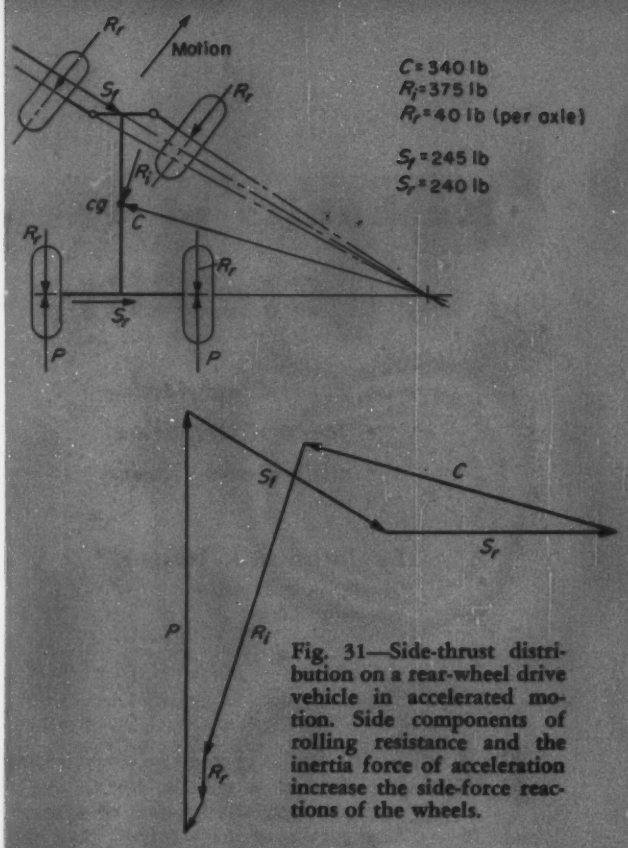

Fig. 31—Side-thrust distribution on a rear-wheel drive vehicle in accelerated motion. Side components of rolling resistance and the inertia force of acceleration increase the side-force reactions of the wheels.

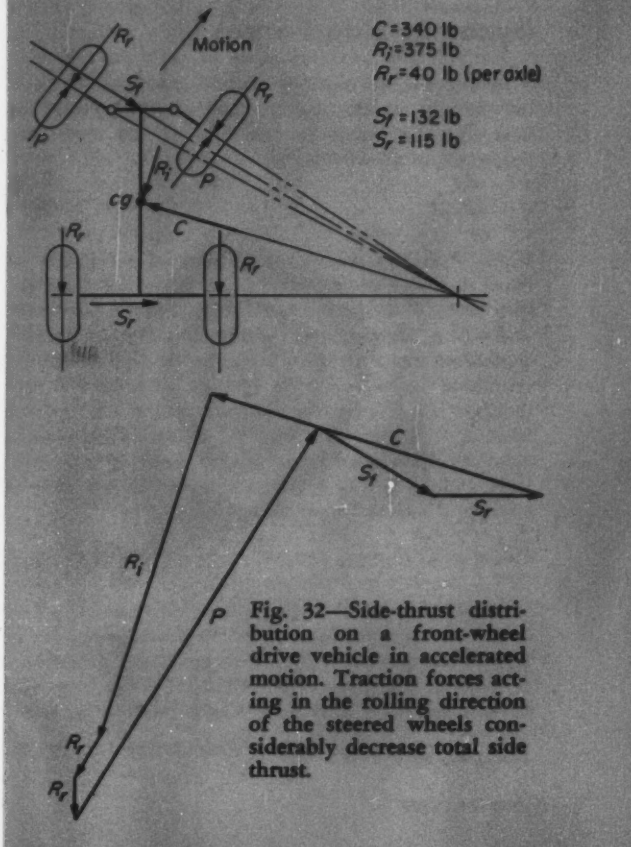

Fig. 32—Side-thrust distribution on a front-wheel drive vehicle in accelerated motion. Traction forces acting in the rolling direction of the steered wheels considerably decrease total side thrust.

strated for two representative cases: (1) rear-wheel drive with front-wheel steering, Fig. 31, (2) front-wheel drive with front-wheel steering, Fig. 32.

Comparing the resultant side forces S_f and S_r with the results of the simplified case (Fig. 30), it is observed that, on the rear-wheel drive car, forces acting at the cg and the rolling resistance of the front wheels all produce side components that increase the side-force reactions. On the front-wheel drive car, on the other hand, traction forces acting in the rolling direction of the steered wheels considerably decrease the side thrust. The rear-wheel drive car will, under the same driving conditions, impose higher side thrusts on the tires than

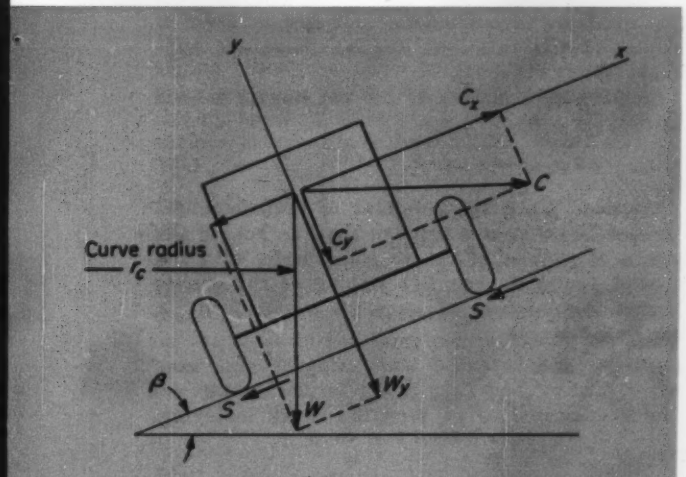

Fig. 33—Balance of forces on a vehicle negotiating a superelevated (banked) curve. Vehicle will slide to the outside of the curve if the resultant of forces acting in the x direction exceeds the maximum frictional side-force reaction.

will the front-wheel drive vehicle. This situation accounts for the well-known superior curve stability of the front-wheel drive, front-wheel steered car.

Other combinations, especially rear-axle steering, four-wheel drive and four-wheel steering may be investigated by the same graphical methods.

Sliding and Tipping Stability

Under some circumstances, the centrifugal force developed on a curve exceeds the maximum cornering capacity of the tires. The vehicle then either slides sideways or tips over. These conditions will be investigated for the general case of a vehicle negotiating a superelevated (banked) curve of radius r_c with constant speed v. Distribution of centrifugal force to the wheels is assumed to be in proportion to the radial-load distribution.

Fig. 33 shows the situation schematically. The limit of the side reaction is determined by the frictional ground force and is therefore given by

$$\Sigma S_{max} = \mu_s(C_y + W_y) \tag{34}$$

where C_y = y component of centrifugal force, W_y = y component of vehicle weight, and μ_s = coefficient of sliding friction.

To prevent the vehicle from sliding sideways, the resultant of forces acting in the x direction must not become larger than the maximum frictional side-force reaction, or

$$(W_x + C_x) \leq \mu_s(C_y + W_y) \tag{35}$$

The relation between centrifugal force (and therefore driving speed) and the superelevation angle β can be obtained when forces in Equation 35 are expressed as functions of β. Conditions for skid-free curve driving can then be calculated.

Minimum Safe Speed: The vehicle must maintain a certain minimum speed to prevent it from sliding down the banked roadbed. The corresponding equilibrium equation developed from Equation 35 is

$$\mu_s(C \sin\beta + W \cos\beta) \geq C \cos\beta + W \sin\beta \tag{36}$$

After substitution of the value of centrifugal force C from Equation 31, minimum speed to prevent sliding becomes

$$v_{s,min} = \left[\frac{gr_c(\tan\beta - \mu_s)}{(1 - \mu_s \tan\beta)} \right]^{1/2} \text{fps} \tag{37}$$

This equation can be further simplified by substituting for the friction coefficient μ_s the tangent of the frictional angle, where

$$\phi = \tan^{-1}\mu_s$$
$$\mu_s = \tan\phi \tag{38}$$

For dry concrete, $\mu_s = 0.7$ and the frictional angle $\phi = 35$ deg. Substituting Equation 38 into Equation 37, converting v from feet per second to miles per hour, and letting $g = 32.2$ ft per sec^2

$$\frac{g^{1/2}(3600)}{5280} = 3.9$$

and the minimum safe speed is

$$V_{s,min} = 3.9[r_c \tan(\beta - \phi)]^{1/2} \text{ mph} \tag{39}$$

In verbal form, minimum speed is proportional to the tangent of the difference between the superelevation angle and the frictional angle.

An interesting application of this stability equation is seen at stunt-driving exhibitions, where a car is driven on a vertical circular wall. The minimum speed required for this stunt can be calculated by substituting $\beta = 90$ deg in Equation 39.

Further, the elevation angle under which the stationary vehicle would just start to slide can be found by substituting $v = 0$ in Equation 37. In this case, $\tan\beta = \mu_o$. Since the system is stationary, the coefficient of static friction applies.

With $\mu = 0.8$ for dry concrete, the stationary vehicle will start to slide at an elevation of 39 deg.

Maximum Safe Curve Speeds: Stability of a vehicle traveling at high speed on a superelevated curve presumes two conditions: (1) speed must not be high enough to cause the vehicle to slide up the slope of the superelevation, and (2) speed must not be high enough to tip the vehicle about the outside wheels. These conditions are examined in the following sections.

SLIDING: Equilibrium equation for the case where the vehicle tends to slide up the slope of the superelevation is

$$(C \sin \beta + W \cos \beta)\mu_s \geq C \cos \beta - W \sin \beta \qquad (40)$$

where

$$C = \frac{mv^2}{r_c}$$

After simplification

$$v_{s,\max} = \left[\frac{gr_c(\tan \beta + \mu_s)}{(1 - \mu_s \tan \beta)} \right]^{1/2} \qquad (41)$$

and, since the frictional angle is related to the friction coefficient by

$$\mu_s = \tan \phi$$

then

$$V_{s,\max} = 3.9[r_c \tan (\beta + \phi)]^{1/2} \text{ mph} \qquad (42)$$

Maximum safe speed is therefore proportional to the tangent of the sum of the superelevation angle and the frictional angle. With speed increasing to infinity ($v = \infty$) it can be found from Equation 40 that the superelevation need not exceed the value

$$\beta = \cot^{-1} \mu_s \qquad (43)$$

For the hypothetical case of complete absence of friction, a superelevation angle can still be found that permits safe vehicle operation. In such a case, the resultant of all forces is exactly perpendicular to the road surface. Substituting $\mu_s = 0$ into Equation 40, the ideal superelevation angle becomes

$$\beta = \tan^{-1} \left(\frac{v^2}{gr_c} \right) \qquad (44)$$

The existence of a frictional side-support force is nonessential in this case, and maximum and minimum speeds are equal.

Simplifying Equation 42 for the case of a level surface ($\beta = 0$),

$$V_{s,\max} = 3.9(r_c \mu_s)^{1/2} \text{ mph} \qquad (45)$$

TIPPING: When the resultant of horizontal and vertical forces passes through the line joining the points of contact of the outside wheels with the ground (point *A*, Fig. 34) tipping of the vehicle begins. Equilibrium of moments about point *A* can be written as

$$nR_y - HR_x = 0 \qquad (46)$$

$$R_x = C \cos \beta - W \sin \beta$$

$$R_y = C \sin \beta + W \cos \beta$$

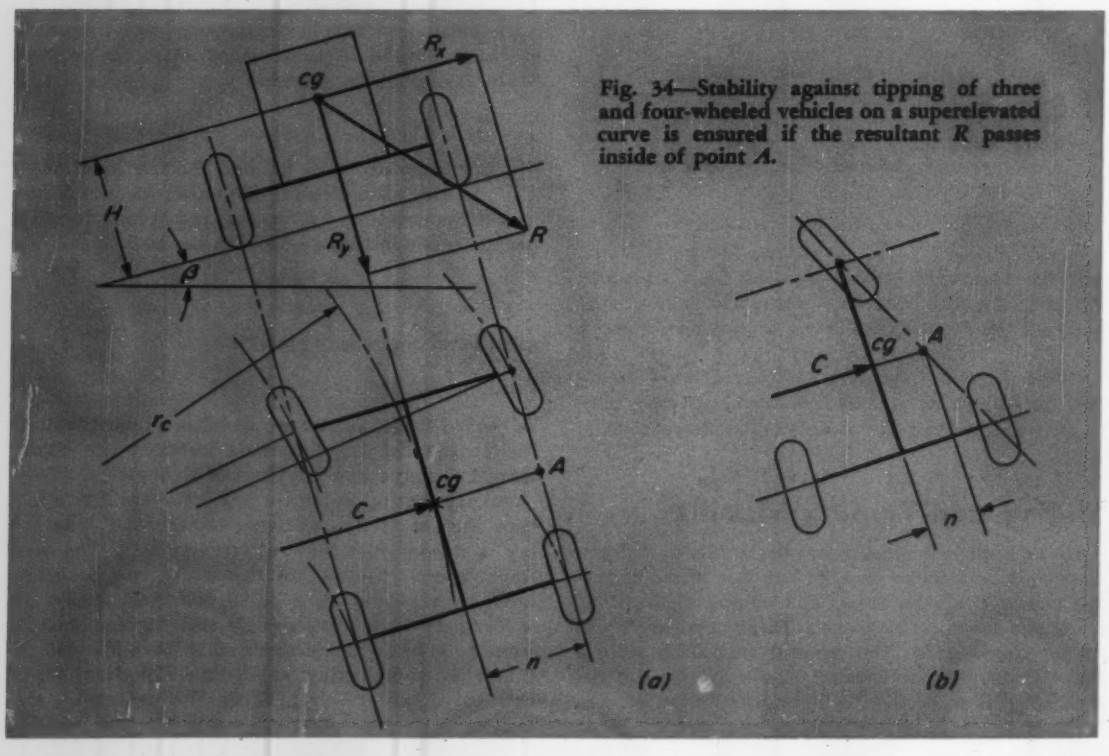

Fig. 34—Stability against tipping of three and four-wheeled vehicles on a superelevated curve is ensured if the resultant *R* passes inside of point *A*.

where n is the projected distance between A and the center of gravity, and R_x and R_y are the force components in the x and y directions. These components are given by

After substitution of these results in Equation 46, the critical speed of tipping becomes

$$v_{t,\max} = \left[\frac{g r_c (n + H \tan \beta)}{(H - n \tan \beta)} \right]^{1/2} \quad (47)$$

Simplifying again for the case of a level surface ($\beta = 0$),

$$V_{t,\max} = 3.9 \left(\frac{r_c n}{H} \right)^{1/2} \text{ mph} \quad (48)$$

Comparison of Equations 41 and 47 will reveal whether tipping or sliding will occur first as the speed of the vehicle increases. It is desirable that sliding occur first. This happens when speed that induces sliding is reached sooner than the critical tipping speed, that is, $v_{tmax} > v_{smax}$. For a level surface, this results in the condition

$$\frac{n}{H} > \mu_s \quad (49)$$

In the preceding equations, the vehicle is assumed to be moving with constant speed, no tractive or braking forces are being simultaneously transferred, and the centrifugal force is distributed on the axles in the same proportion as the static level axle weights. Should this not be the case, the distribution of centrifugal side thrusts to the individual axles will have to be determined, and the safety against sliding examined for each wheel separately. The wheel with reduced dynamic load (due to a hill, trailer pull, etc.) will start to slide first. Other conditions being equal, the driving or braking wheel with lower effective μ values will slide first. Further, for the coefficient of friction μ_s, only such values can be taken for the side forces that remain after vectorial subtraction of the portion already taken by tractive or decelerating forces. It is interesting to note also that all critical speeds are independent of vehicle weight.

With increasing vehicle speed, sliding usually starts before tipping on most passenger cars. On trucks, however, where H is large, the critical tipping speed may be reached sooner.

Tipping properties of four-wheeled vehicles with pivoted steering axles (e.g., lift trucks) are similar to those for a three-wheeled vehicle. In such a case, the central pivot point and not the wheels forms the effective front-end support against tipping.

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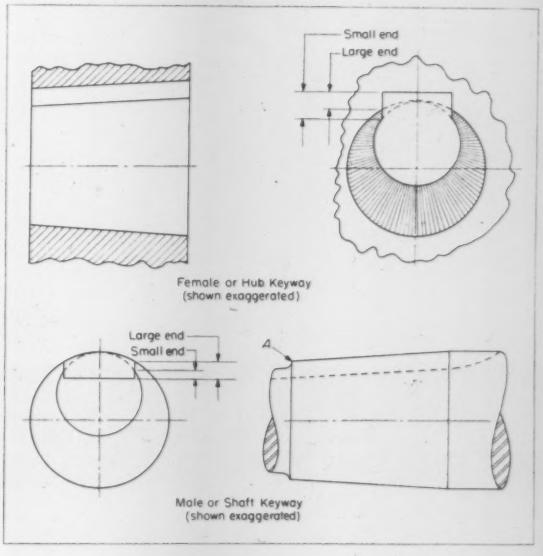
Tips and Techniques

Dimensioning Keyways

When dimensioning the depth of keyways on tapered shafts, it is necessary to specify where the depth is to be measured. As shown, the keyway depth, for both internal and external tapers, varies from end to end. Inasmuch as it is common practice to have the keyway depth in cylindrical male and female members equal, or nearly so, special dimensioning is required for tapered parts.

In the tapered hole shown, the keyway depth at one end can be readily dimensioned and the part easily checked. However, in the tapered shaft shown, checking the part may require special gages as there are no square corners to act as reference points. For good interchangeability, the designer should either incorporate a square corner on the shaft, perhaps at point A, or realize that inspection problems may result when checking the part.—GEORGE PHEIL, *Racine, Wis.*

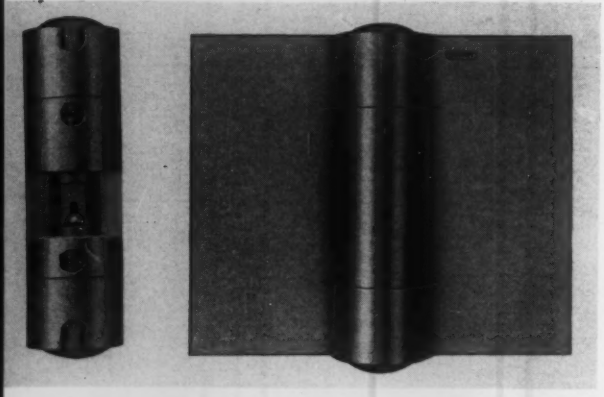


Basic facts about design and specification of

Special Hinges

Fig. 1—Small hinge units designed to meet minimum size and thickness requirements. Leaves of top hinge are 0.015-in. thick. Size of small hinge at lower right is 3/4 by 3/4 by 0.025-in.

Fig. 2—Extra heavy-duty hinge for severe load and service conditions. Hinge material is triple-weight, 0.275-in. thick, cold-rolled wrought steel with cyanide case. Ball-bearings in middle knuckle assure smooth operation and prevent wear at joint. Oval-head pin is made of two sections of 3/4-in. hardened steel rod locked in position with the ball bearings by a force fit. Assembled weight is 5 lb. Two of these hinges are capable of carrying door members weighing up to a ton.

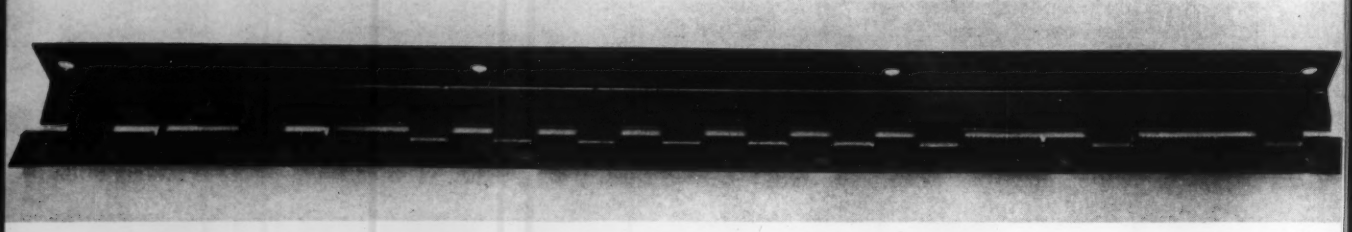


ALTHOUGH generally classified as "hardware," hinges serve a number of basic functions in design. In conventional form, they provide a simple solution to the problem of mounting and supporting access doors, panels and similar members that must operate freely about a pivot axis. Other important uses include service as a locking device or as a "decorative" component to enhance product appearance and acceptance.

In many design situations, hinge requirements can be filled by one of various standard catalog forms. But where unorthodox bends, configurations, holes, profiles and other unique features are necessary for function or appearance, a special hinge is usually called for.

Great latitude is offered in design by present hinge manufacturing equipment and techniques which can be readily adapted to economical production of special hinges in widely varying sizes, shapes and materials. Typical possibilities range from extremely small and simple light-duty units, Fig. 1, to: extra heavy-duty assemblies for severe load and service conditions, Fig. 2; continuous hinges for rigidity and appearance, Fig. 3; or unusual leaf configurations for special mounting

Fig. 3—Continuous hinge with spring closing features. Made in almost any length, this special hinge form offers a rigid construction of clean, neat appearance.



Production Considerations
Design Practices
Materials and Finishes

By A. I. Olson
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requirements, Fig. 4. A review of production considerations and recommended practices in the design and specification of such special hinge forms is presented here.

Production Considerations: Sequence of operations in the production of a typical hinge assembly, as well as basic hinge nomenclature, are illustrated in Fig. 5. Minimum quantities for economical production of special hinges on machines specifically set up for the job range from 1500 to 2000 pieces. Smaller quantities can be produced but increase in unit costs may be appreciable.

Special shapes shown in Fig. 6 are representa-

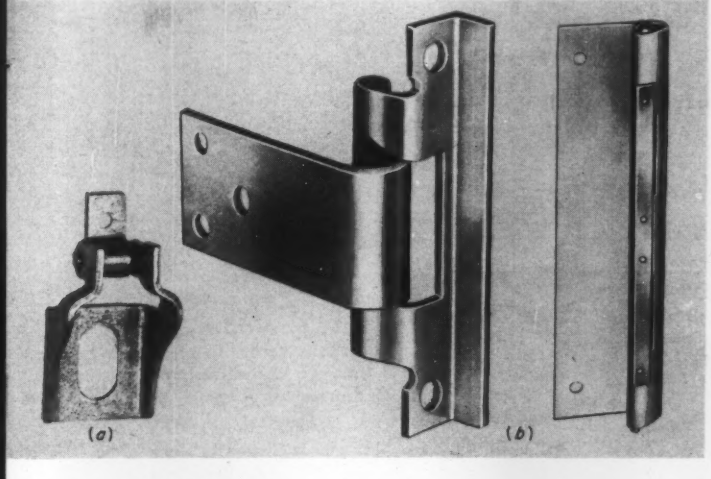


Fig. 4—Hinge designs developed to meet special mounting requirements. Construction at *a*, which is used on textile machine covers that are often 100 ft long, has a large hole in leaf for accurate adjustment of cover alignment. Concealed hinges, *b*, have curved leaf to fit space occupied in both closed and open positions.

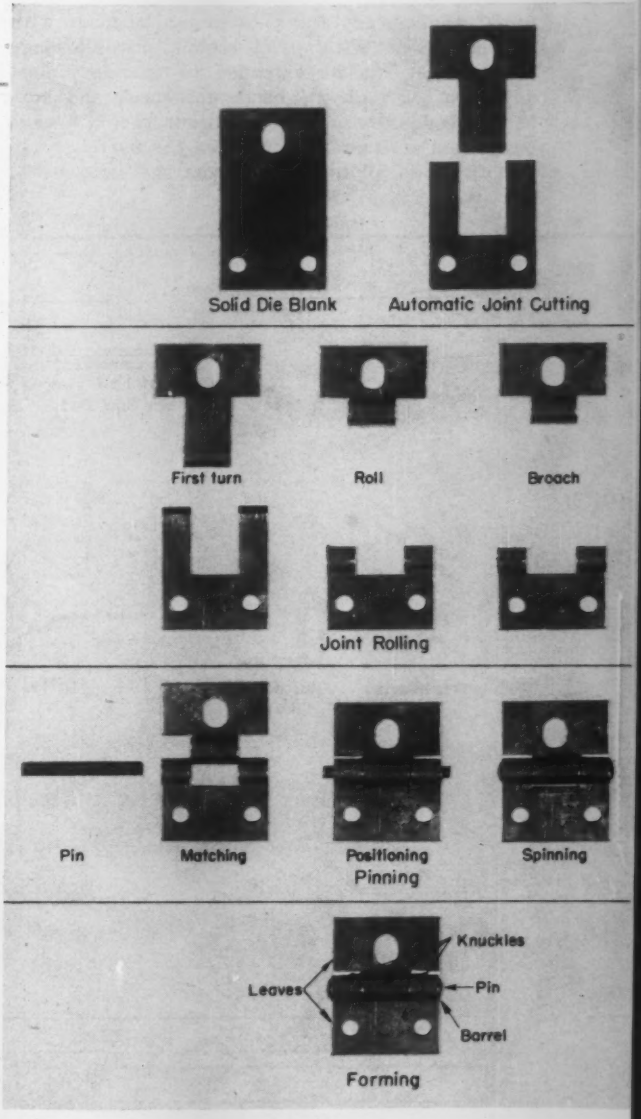


Fig. 5—Sequence of production operations, and basic nomenclature, for a typical hinge assembly. Both joints are cut from blank simultaneously. In spinning operation, pins are locked in position by peening ends over.

tive of modifications that can be readily performed on hinge leaves to meet specific application requirements. Leaf widths from ¾ to 10 in. can be produced with a single machine operation. Larger widths require an extra machine operation. Actually, from a production standpoint, there are no limitations, within reason, on the size of a special hinge.

Swaging or offsetting operations can be performed in conjunction with the rolling and broaching of the barrel. High-production bending is also possible without special tooling. A number of different angle bends and off-sets can be made with standard tools. With special tooling, possible range of variation can be extended to include almost any form of radius, Z-bend, gooseneck and box-shaped bends. In either case, bends should always be located at least 3/16-in. from the barrel.

Both hinge joints are cut from the same stock, Fig. 5, since almost all hinge joints, even in special hinges, are symmetrical opposites. Hinge leaves of unequal width present no particular problem in either design or machining. A virtually infinite number of ornamental and special end-configurations can be produced with special tooling and practically all types of curved profiles are common in the manufacture of special hinges, Fig. 7. Configurations are produced by a blanking tool or, if necessary, they are trimmed to shape after joint cutting and rolling operations.

Hinge barrels with diameters up to 0.650-in. can generally be rolled in one operation. Larger diameters may require additional passes. Bends cannot be formed on barrels.

Standard clearance between leaves and barrel is 1/32-in., but this dimension can be readily varied to meet any requirement. This applies to both swaged or barrel-boosted hinges.

A clearance of 0.013-in. is normally broached between knuckles. The standard swage is equal to

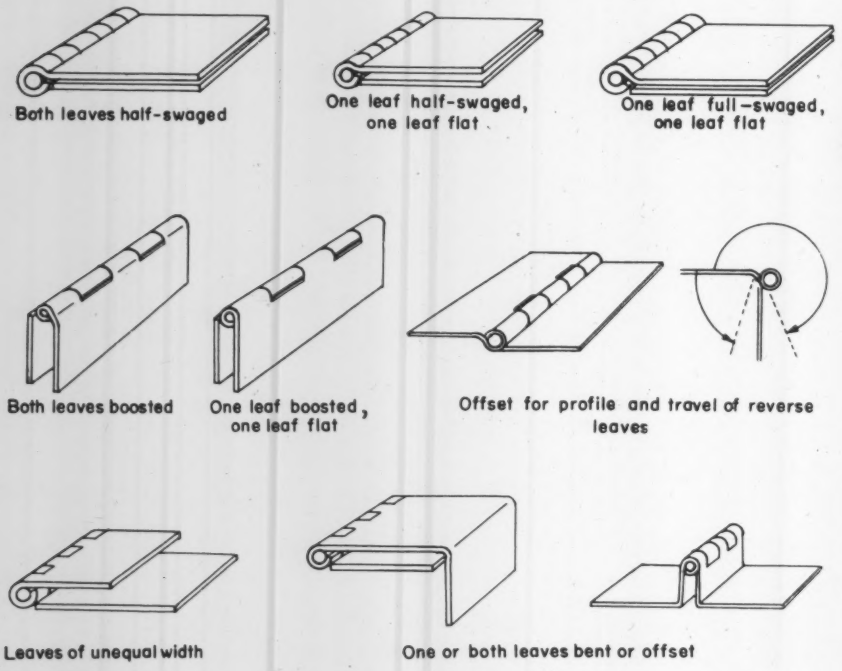

Both leaves half-swaged
One leaf half-swaged, one leaf flat
One leaf full-swaged, one leaf flat
Both leaves boosted
One leaf boosted, one leaf flat
Offset for profile and travel of reverse leaves
Leaves of unequal width
One or both leaves bent or offset

Fig. 6—Representative shape modifications that can be performed on the leaves of special hinges. Swaging is used to reduce the space between leaves when closed, barrel "boosting" to increase this space.

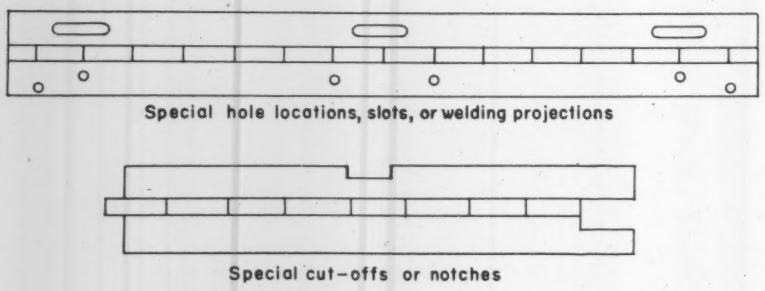
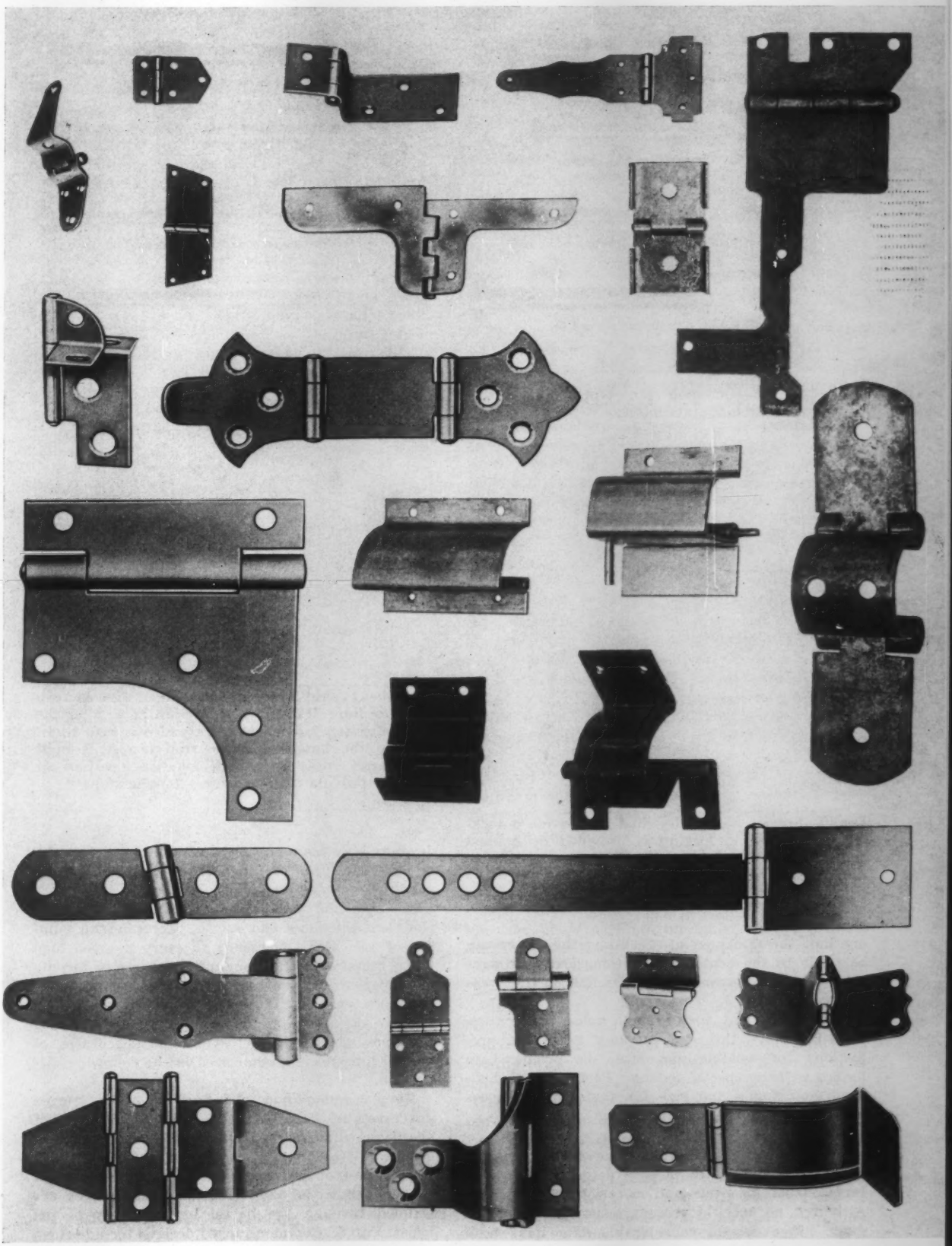


Fig. 7—Typical end configurations and profile variations that can be produced on special hinges.



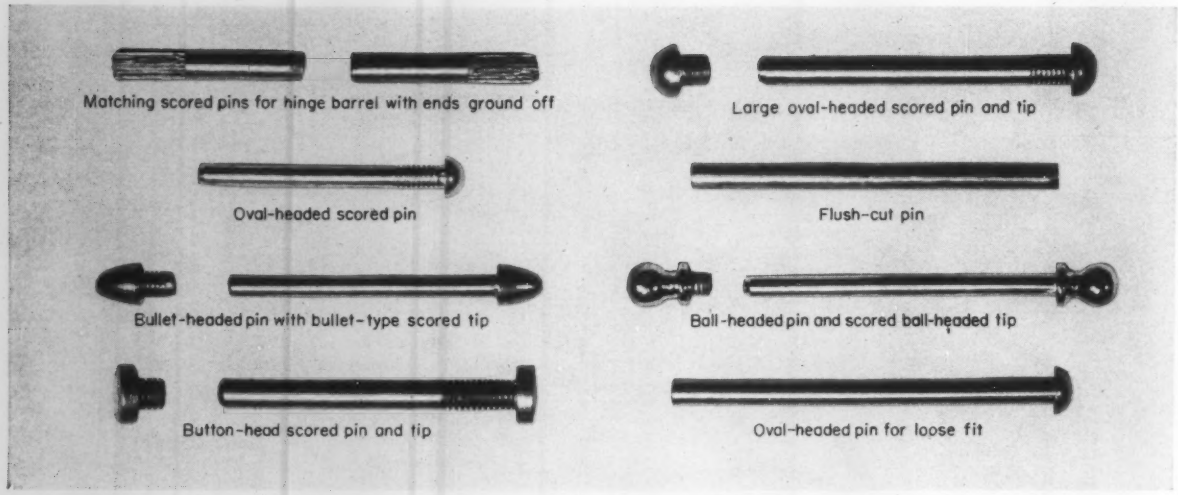

Matching scored pins for hinge barrel with ends ground off
Large oval-headed scored pin and tip
Oval-headed scored pin
Flush-cut pin
Bullet-headed pin with bullet-type scored tip
Ball-headed pin and scored ball-headed tip
Button-head scored pin and tip
Oval-headed pin for loose fit

Fig. 8—Common pin types used in hinge assemblies.

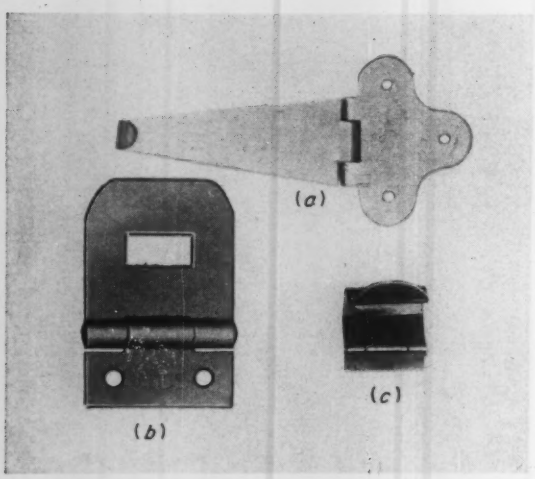


Fig. 9—Special hinges designed to provide a locking action. At *a*, locking is provided by hooked end which is slightly angled. Design at *b* is simple hinge hasp, that at *c* a clip lock.

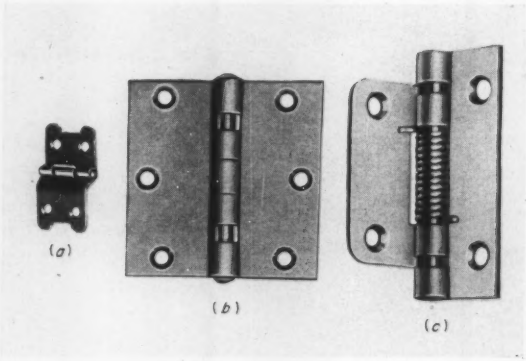


Fig. 10—Typical hinge constructions with built-in stops to limit leaf movement. Stop at *a* is in the form of a separate metal piece which is bent to fit between the knuckles. At *b*, stop feature is built into barrel while at *c* both knuckles are half-cut away to provide clearance for a tongue stop.

one half the thickness of stock and the swage can be made to the center line automatically. Hinges can be swaged beyond the center line on the press operation.

Both plain and countersunk holes for screws, slots for bolts, threaded extruded holes and projections for welding can often be produced in hinges without special tooling. Perforations of almost any shape and size for fastening purposes are possible with special tooling.

Hinge Design: Size limitations on the components of a hinge are largely determined by the functions of its parts and material specifications. Although no specific procedure can be offered to guide hinge design, considerable data have been developed by manufacturers on the characteristics of different types of hinge assemblies for varying conditions of application.

In establishing the size of a hinge—pin dimension, leaf thickness and length, barrel height, number of knuckles—necessary to carry a given load for a certain function, manufacturers rely heavily on experience in analogous situations. Load ratings, are usually quite conservative to provide a margin of safety in application. Recommended practices and other factors influencing design of special hinges are summarized in the following discussion.

Typical commercial tolerances for special hinges are given in Table 1. Note that the method of specifying dimensions controls the production tolerance.

Thickness of metal employed for hinges is usually between 0.030 and 0.250-in. Hinge leaves are coupled through the barrel by a variety of pin types, Fig. 8. Commonly used designs include flush

pins, preferably scored; oval head pin; oval head pin and tip; button head pin and tip; and oval and flat spun pins which are riveted. Flush and oval head pins are secured by scoring and staking in slip-joint hinges where the pin is tight in one leaf and loose in the other.

Recommended pin diameter is at least 1½ times the thickness of leaf stock. Typical size range of pin diameters is from a minimum of 0.078-in. to a maximum of ½-in.

Knuckle length is also determined by material thickness, with a minimum of approximately ¼-in. recommended as a practical limit. The problem of "how many knuckles" is definitely related to how the hinge is to function. In conventional door applications, for example, the five-knuckle hinge has been found superior to the three-knuckle design when all factors, including materials and manufacturing costs, are considered. With a five-knuckle hinge, the three-knuckle side is attached to the jamb member. This results in a better fit for the matching knuckles and a more even distribution of wear on the bearing surfaces. The pin in this case is anchored securely and is able to take a high lateral thrust due to the door's weight.

However, these problems are not always true in the design of special hinges where application requirements may vary greatly. For instance, in hinges designed for horizontal rather than vertical mounting, the thrust problem is much less critical. Other hinges which are used merely as locking devices, Fig. 9, may have no thrust problem at all.

Table 1—Typical Commercial Tolerances for Special Hinges

Quantity	Tolerance
General Dimensions, Hinge Width, Slots	
Fractional dimensions	±0.015-in.
Two decimal places	±0.010-in.
Three decimal places	±0.005-in.
Hole Sizes	
Fractional dimensions	±0.010-in.
Two decimal places	±0.005-in.
Three decimal places	±0.003-in.
Angles	±½-degree

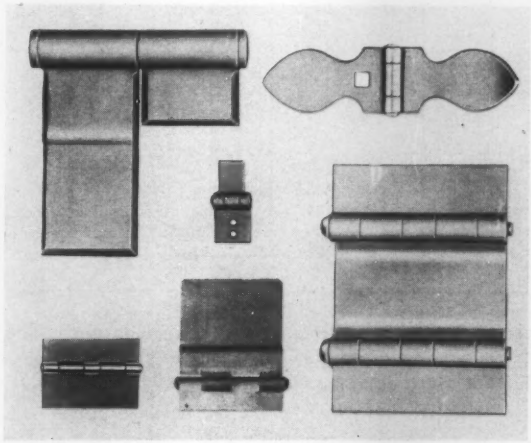


Fig. 11—Typical hinge designs for fastening by welding.

Stop features can be incorporated in the barrel, or in the form of a welded element on an opposing leaf, to limit the travel of one or both leaves. Opposing leaves may also be formed or extruded to limit movement. Representative designs with built-in stops are shown in Fig. 10.

Coil springs, loaded in either direction, are usually employed when tension is desired in a hinge, Fig. 3. Leaf or flat springs are also used for this purpose. Space in the barrel is provided for the spring which is mounted by slipping the pin through barrel and spring, the spring ends being first set in place. Leaf springs are usually held in place by rivets, by lanced and formed clips or by ears.

Practically every type of fastening method can be used to mount hinges. Wood screws, machine screws, rivets and integral studs and barbs are the most commonly used "projecting" fasteners. For household products, such as washing machines and dish washers, spot welding is generally preferred. On industrial equipment and in other applications where maximum strength of mounting is required, arc welding is often the best method. Typical hinge designs for fastening by welding are shown in Fig. 11.

Materials and finishes: Common materials used for hinges include steel, brass, bronze, stainless steel and copper in combination, and aluminum alloys. Optimum design for a hinge requires that the material have maximum hardness and still be soft enough so that the hinge joints can be easily rolled. Cold-rolled steel, AISI 1010 and 1015, is the best suited material from this standpoint, and the most widely used.

Small hinges which are required to have high strength are often made of 1050 steel with a Rockwell C 54 hardness. This steel, with its good spring-temper characteristics, was used to advantage originally in a heavy-duty sewing machine hinge.

All of the AISI steels have been employed in hinges. In military applications, 4130 or 4150 steels have been specified for parts such as parachute buckles or components of parachute harnesses that utilize a type of flexible hinge. On the 50-caliber machine-gun bullet belt, the links, which have a hinge function, are made from 1050 steel.

Hinges which have a plain knuckle are usually cold-rolled steel of Rockwell B 85-95 hardness and between No. 1 and No. 2 temper. Hinges with a sharp bend in addition to the rolled joint are usually Rockwell B 60-75 with a No. 3 temper. For extreme requirements there are many variations of these two specifications depending upon design conditions. Some hinge parts must be semiannealed locally when a sharp bend is to be made. It is common to have brass or bronze pins in steel hinges to provide a freer hinge action.

Other common hinge materials are two ASTM B-36 compositions: Alloy No. 6 brass and alloy

No. 2 bronze. Magnetic and nonmagnetic stainless steels have also found application in hinge service. Nonmagnetic stainless is often specified in continuous hinges for small sea-going craft and cruisers, both for the nonmagnetic quality and corrosion resistance. Aluminum alloys suitable for hinges include, among others, 6061 and 5052, the latter being used for certain types of continuous hinges.

Finishes for special hinges offer still another group of design options. Bronze, brass and stainless steel materials retain their natural finishes and are usually polished and buffed to bring out their lustre. The most economical applied finishes are japanning, painting and lacquering. Bonderizing before painting is common practice and Parkerizing, a heavier finish of similar type, provides integral rust protection of hinge surfaces without painting.

Copper, nickel, chrome, zinc and cadmium plating are also used. Bright zinc is one of the more common finishes. For maximum corrosion resistance plus beauty, some hinges are plated with a layer of copper, a layer of nickel and a top layer of chrome. Aluminum hinges are anodized, and irridescent color designs are possible.

Tips and Techniques

Simplified Perspectives

A simple and accurate perspective view may be drawn without the use of two orthographic accompanying views, such as the top and right-side views.

1. Drawing a cube as an example, lay out a horizontal line and locate a left vanishing point, *L*, and a right vanishing point, *R* on it, Fig. 1.

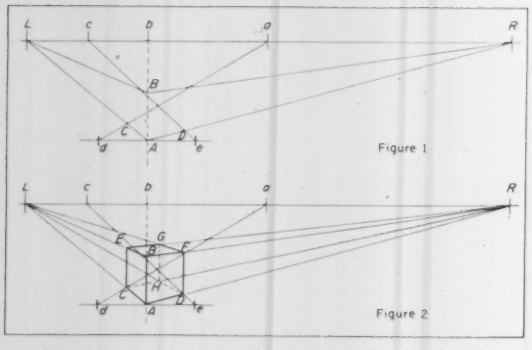
2. Bisect line segment *L-R* to locate point *a*.

3. Bisect line segment *L-a* to locate point *b*, and bisect line segment *L-b* to locate point *c*.

4. On a vertical line through point *b*, locate point *A*. This is the lower corner of the construction. Measuring directly on line *b-A*, locate point *B*, the upper corner of the object.

5. Project points *A* and *B* to *L* and *R*.

6. Through *A*, draw a horizontal line. Measuring from point *A* on this line and using the actual length of the left side of the object, locate point *d* to the left of *A*. Point *e* is located to the right of *A*, with distance *A-e* equal to the length of the right side.



7. Project point *d* to point *a* and point *e* to point *c*.

8. Line *a-d* intersects line *L-A* at point *C*; line *c-e* intersects line *R-A* at point *D*.

9. Project point *C* up to intersect line *L-B*, giving point *E*, Fig. 2. Project point *D* up to intersect line *R-B*, giving point *F*.

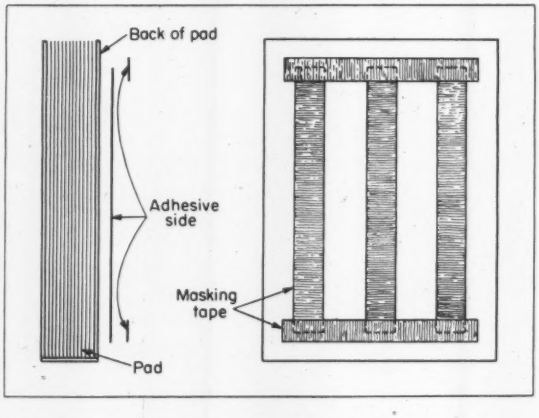
10. Project lines from points *C* and *E* to *R* and points *D* and *F* to point *L*.

11. A vertical line, *G-H*, joining the intersections of the last two pair of projections completes the construction.

This method may be used to block in an object of any shape. The object may also be viewed from any angle. To show the left side of the object, locate bisections *b* and *c* to the right of center. To look at the bottom of the object, make the construction above the horizontal line.—JOHN MULLIGAN, *Chicago*

Nonskid Scratch Pad

When taking one-handed notes on a scratch pad, the tendency of the pad to move can be annoying. This can be remedied by fastening 2 or 3 strips of tape to the back, adhesive side out. The tapes are held in place by others at the ends.—EWALD SCHLACHTER, *Oshkosh, Wis.*



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Nomographs for calculating

Stress in Rotating Cylinders

Carrying Liquid Loads

By E. V. Garner
Centrifugal Div. Engineer
Bird Machine Co.
South Walpole, Mass.

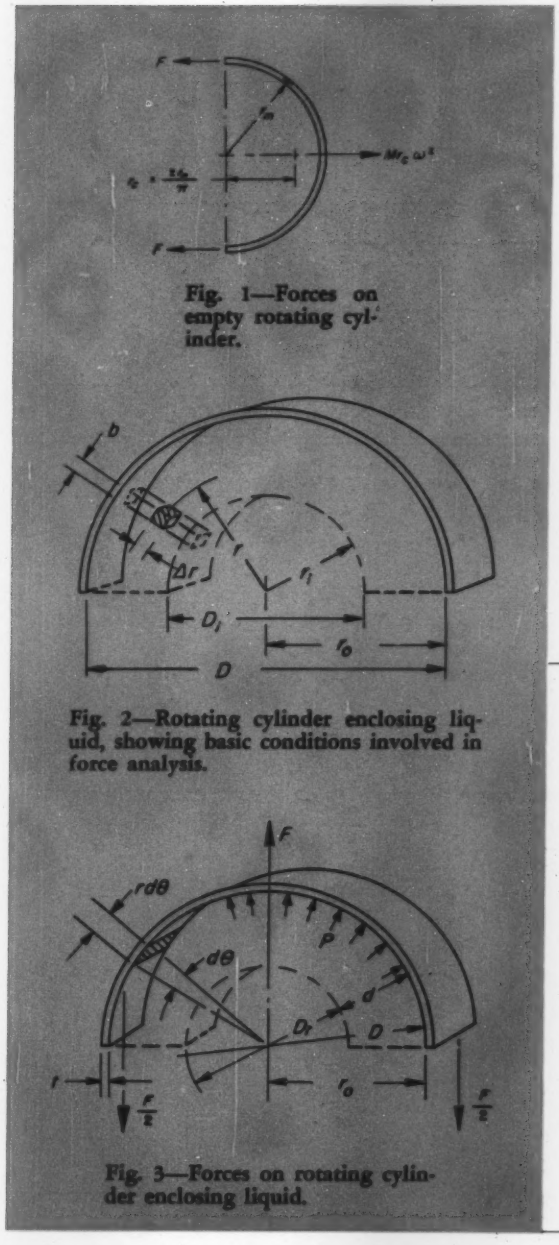


Fig. 1—Forces on empty rotating cylinder.

Fig. 2—Rotating cylinder enclosing liquid, showing basic conditions involved in force analysis.

Fig. 3—Forces on rotating cylinder enclosing liquid.

STRESSES resulting from rotation of thin-walled, cylindrical machine components, carrying a liquid load, can be found quickly from the nomographs in this article.

The charts pertain to equipment such as centrifugal filters and related machinery in which self-induced inertia forces and the liquid contained cause significant values of rim tension during rotation.

Two nomographs are presented: one for self-induced stress and one for stress caused by con-

Nomenclature

d = Radial mean depth of liquid, in.
D = Diameter, in.
D_i = Inside diameter of contained liquid, in.
D_m = Mean diameter of cylinder, in.
F = Force, lb
g = Acceleration of gravity, in. per sec^2
M = Mass, lb-sec^2-in.
m = Mass per unit volume, lb-sec^2-in.^{4}
N = Speed, rpm
p = Pressure, psi
r = Radius, in.
r_c = Centroidal radius of one-half cylinder rim, in.
r_i = Inside radius of contained liquid, in.
r_m = Mean radius of cylinder, in.
r_o = Outside radius of contained liquid, in.
S = Total tangential stress, psi
S_1 = Self-induced stress, psi
S_2 = Stress due to contained liquid, psi
t = Cylinder wall thickness, in.
W = Weight, lb
δ = Density of cylinder wall material, lb per cu in.
ω = Angular velocity, radian per sec

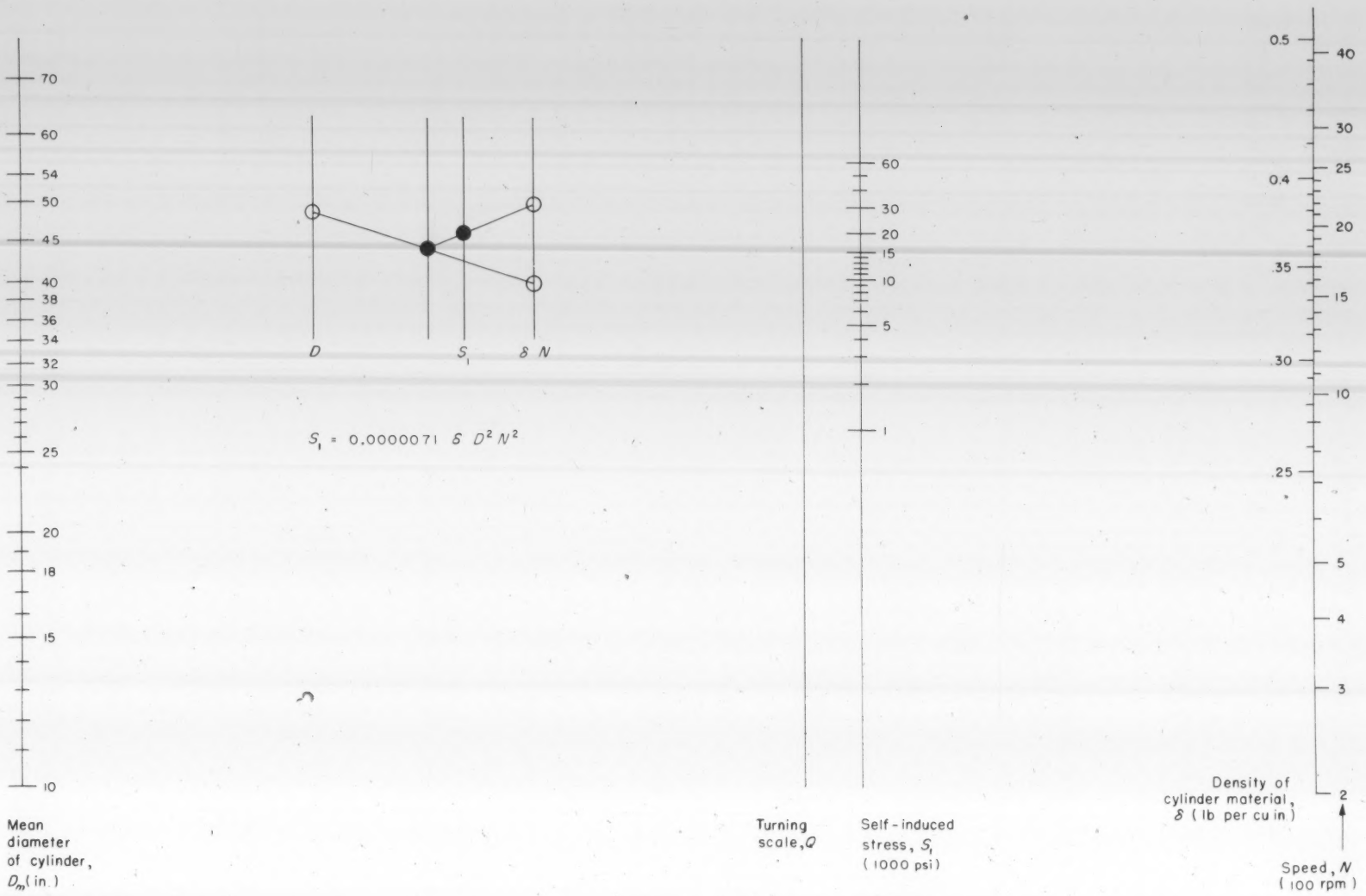


Fig. 4—Nomograph for self-induced stress in cylinder wall due to rotation.

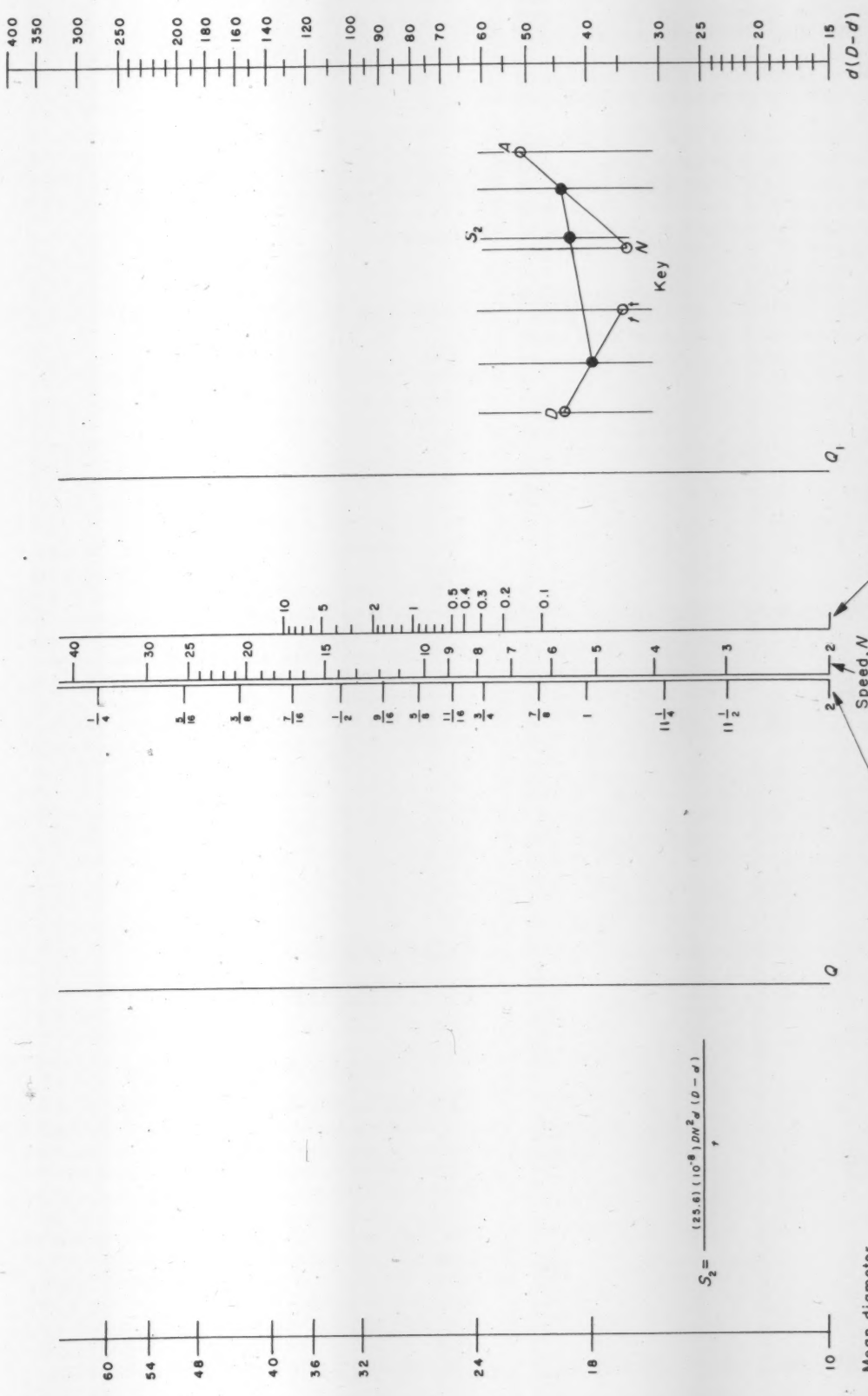


Fig. 5—Nomograph for stress in cylinder wall due to rotation of enclosed liquid.

tained liquids. The summation of these two represents the total tangential stress in the cylinder.

Stress without Liquid Load: A brief development of the basic equation is given here to review certain fundamentals.

Fig. 1 represents one-half the rim of a hollow rotating cylinder. The restraining force on each cross section is F. The inertia force due to the centrifugal component of acceleration, $r_c\omega^2$, must be equal and opposite to $2F$. Then $2F = Mr_c\omega^2 = (W/g)r_c\omega^2$ where W is one-half the total rim weight.

For thin cylinders, the rim thickness is small in comparison with the mean radius r_m. No significant error is introduced by taking the mass center of the rim at the centroid of the 180-degree arc where $r_c = 2r_m/\pi = D_m/\pi$.

Therefore

$$2F = \frac{WD_m\,\omega^2}{\pi g} \text{ or } F = \frac{WD_m\,\omega^2}{2\pi g}$$

The unit stress is F/A, and for a rim of unit length,

$$S_1 = \frac{WD_m\,\omega^2}{2\pi gt} = \frac{\pi D_m t\,\delta\,D_m\,\omega^2}{4\pi gt}$$

or

$$S_1 = \frac{\delta D_m{}^2\,\omega^2}{4g}$$

In practical units,

$$S_1 = (7.1 \times 10^{-6})\,\delta D_m{}^2\,N^2$$

Stress Due to Rotating Liquid Load: At the ID of the cylinder shown in Fig. 2, the pressure at r_o can be found by considering a unit length of cylinder and an elemental column of liquid. The force at any radius r is ΣMa from r_i to r_o, where a is the centrifugal component of acceleration, $\omega^2 r$, and the elemental mass is $mb\Delta r$. At r,

$$p = \frac{dF}{dA} = m\omega^2 \int_{r_i}^{r_o} r\,dr$$

Then, for a partially filled cylinder,

$$p = \frac{m\omega^2\,(r_o{}^2 - r_i{}^2)}{2}$$

and, for a full cylinder, where $r_1 = 0$,

$$p = \frac{m\omega^2\,r_o{}^2}{2}$$

To find the resulting tangential stress, the force due to pressure p is determined with reference to Fig. 3. The increment of force $dF = p\,dA = p\,r_0\,d\theta$, and the vertical component, opposite to F, equals $p\,r_o \cos\theta\,d\theta$.

$$F = \int_{\theta=-\pi/2}^{\theta=+\pi/2} pr_o \cos\theta\,d\theta = 2pr_o$$

and

$$S_2 = \frac{F}{2A} = \frac{2pr_o}{2t} = \frac{m\omega^2\,(r_o{}^2 - r_i{}^2)\,r_o}{2t}$$

In practical units,

$$S_2 = \frac{(1.78 \times 10^{-6})\,(\delta N^2\,D)\,(D^2 - D_i{}^2)}{t}$$

By taking $(D - D_i)/2 = d$ = radial depth of the liquid, and, by using $\delta = 0.0361$ lb/cu in. for a water load, the nomograph can be simplified. Stress due to a liquid other than water can always be found by multiplying the nomograph solution by its specific gravity.

Therefore,

$$S_2 = \frac{(25.6)\,(10^{-8})\,DN^2\,d(D - d)}{t}$$

Total tangential stress is the sum of S_1 and S_2.

Example: To illustrate the use of the nomographs, assume:

Cylinder wall thickness, t	½-in.
Cylinder inside diameter, D	40 in.
Speed, N	1200 rpm
Radial mean depth of liquid, d	4 in.
Density of cylinder wall material, δ	0.28 lb per cu in.
Specific gravity of liquid	1.25

To determine the self-induced stress, in Fig. 4 connect $D_m = 40.5$ in. and $N = 1200$ rpm and mark the point where the line crosses the turning scale Q. From this point draw a straight line through the density scale at $\delta = 0.28$ and read $S_1 = 4700$ psi on the self-induced stress scale.

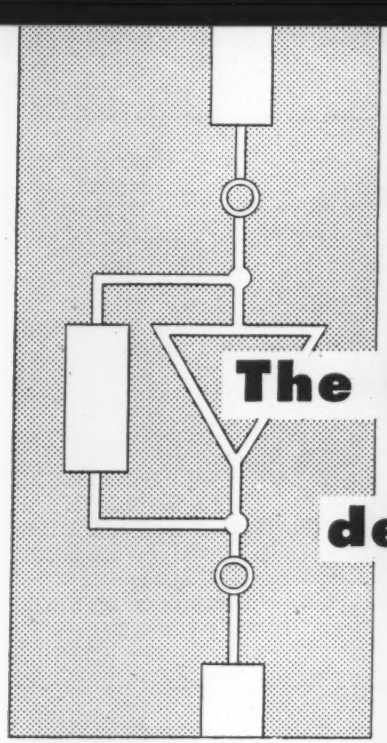
Use Fig. 5 for the stress due to liquid load, S_2. First evaluate $d(D - d) = 4(40 - 4) = 144$. Connect this point with $N = 1200$ rpm and mark the intersection on scale Q_1. Mark Q on the straight line between cylinder ID = 40 in. and thickness t = ½-in. Connect the points on Q and Q_1, and read $S_2 = 4400$ psi on the load stress scale. When corrected for specific gravity, $S_2 = 1.25\,(4400) = 5500$ psi.

The total stress $S = S_1 + 10{,}200$ psi.

Tips and Techniques

Keeping Board Covers Taut

A simple system may be used to keep the cover of a drawing board tight and free from ripples caused by changing weather conditions. One end of the cover is fastened semipermanently to the board with thumb tacks or staples. The opposite end is punched with a series of holes, spaced from 4 to 8 in. apart. The holes are strengthened by a gummed reinforcement on each side. One or two rubber bands per hole are then looped through the holes, depending on the size of the board. The free ends of the rubber bands are hooked over thumb tacks on the underside of the board.—D. W. LOUGHLIN, *Cochrane Corp., Philadelphia.*



The analog computer • • • design-problem solver

By Walter Noon
Process Development Staff
General Motors Corp.
Detroit

MANY problems which an engineer encounters in design can be readily solved by applicaton of past experiences coupled with rough calculations. However, as advancements continue and more complex systems are developed, new problems are met. For the solution of many of these, mathematical analysis is often demanded.

Usually, a skilled analyst can provide a mathematical description in the form of equations which are substantially correct. However, it frequently takes more time than is available to solve the equations and provide quantitative data which are useful in actual practice. Analysis has often been of more value as an aid in understanding a problem rather than as a means of providing useful numerical solutions.

To complete processes begun by analysis, computation is required. High-speed, multipurpose comput-

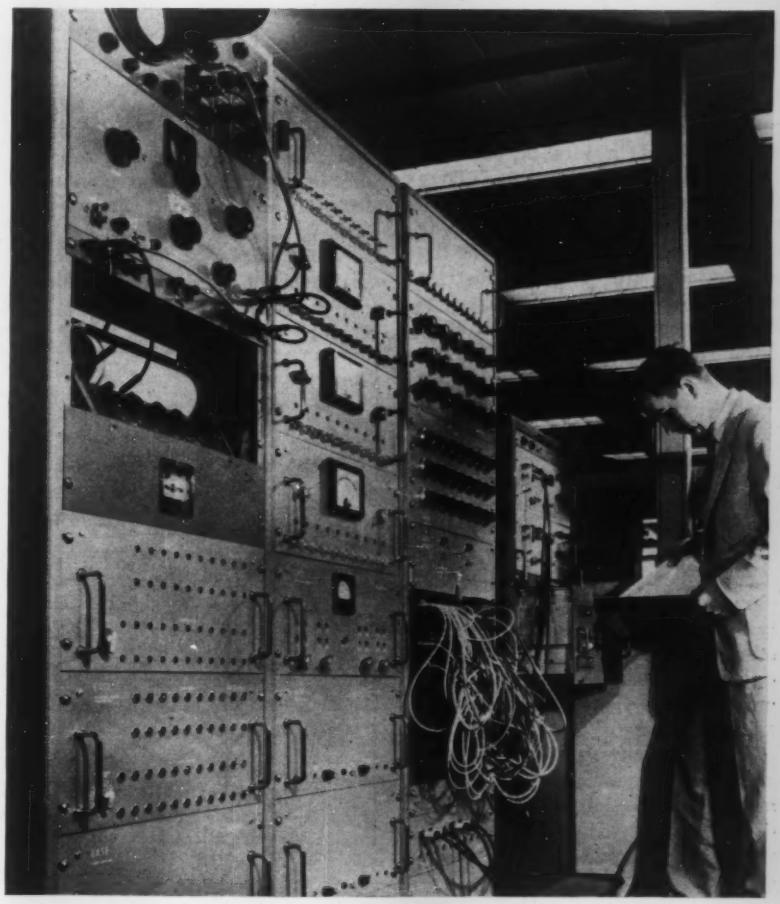


Fig. 1—Right, typical medium-size analog computer installation. Cabinet at right is voltage recorder. Other cabinets contain operational amplifiers, multipliers, function generators, power supplies, and associated computing equipment.

ers now provide means of obtaining quantitative answers to complex design problems.

The analog computer is one of these devices. Analysts with computers at their disposal are able not only to develop mathematical relations which explain physical problems but also to provide specific answers in graphical form.

Analysis explains the general system. Computation tells how well a particular system will perform. Simulation, as provided by the analog computer, enables the design group to help the engineer answer the final question. The particular nature of an analog computer makes it possible to change the constants rapidly in a set of equations. Thus, in effect, components of a system are changed until the combination which gives optimum performance is found.

Briefly then, analysis, computation and simulation can save time and money by giving precise information about a series of proposed systems before any of them are actually built.

Analog Computer Types: Computers may be home-made, or may be purchased in kits or as complete, ready-to-use units. They vary in cost from less than $1000 to approximately $1 million. The area of greatest application for the analog computer is in industries where it is no longer practical to design without the aid of a computer for simulation and design analysis. A typical medium-size analog computer installation is shown in Fig. 1.

The analog computer deals with physical variables such as electrical voltages or rotating shafts, and may be divided into two types: direct and indirect. Direct analogy occurs when problem variables and parameters are represented directly by machine variables and parameters. For example, a direct analogy exists between a mechanical spring mass system and an electrical resistance, inductance, and capacitance circuit, Fig. 2. Indirect analog computers solve, or assist in the solution of, algebraic or differential equations. The slide rule is an example of the mechanical indirect analog computer.

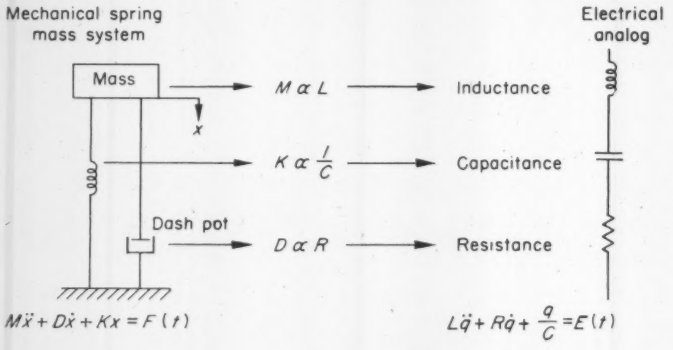


Fig. 2—Direct analogy between mechanical spring mass system and an electrical inductance, capacitance, and resistance circuit. Quantities denoted by x, above left, are displacement of mass, velocity, and acceleration. Similarly, quantities denoted by q, above right, are electrical charge, current, and rate of current change.

The basic computing element of the electronic indirect analog computer is the operational amplifier. With variable voltages and appropriate networks with the amplifier, basic mathematical operations of addition, subtraction, scale and sign change, integration and differentiation can be performed. If function generators, curve followers, and multipliers are available, it is possible to solve single or simultaneous linear and nonlinear differential equations, or to perform specific mathematical operations for various purposes. Many examples of direct and indirect computers are classified under the analog type, Fig. 3.

Computer Problem Solution: Evaluation of a problem for computer solution is as follows:

1. Presentation of the problem with all pertinent material.
2. Mathematical formulation of the problem. Certain problems are solved by direct simulation.
3. Preparation of the problem for computer solution.
4. Analog computer solution of the problem.
5. Application of results to design evaluation.

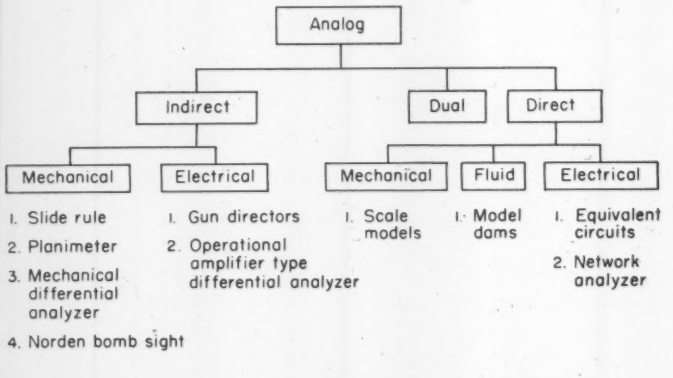


Fig. 3—Analog devices classified as direct, indirect or, in some cases, dual. Classification indicates variety of devices developed. (Reference 1)

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The best way to illustrate the computer's usefulness is to examine the steps necessary to obtain a solution to a specific problem, for example, one concerning design of a cam.

A cam shape is proposed to move a given load, Fig. 4. The designer is not certain, however, that the load will be moved smoothly, and a performance evaluation is desired. In addition, the designer wants to know what alternate cam shape will be satisfactory if the proposed shape fails to provide smooth motion.

An equation is next derived by equating forces acting on the cam follower. It is quite difficult to solve this equation by conventional mathematical methods. Also, it would be extremely time-consuming to solve for a variety of shapes. However, the equation can be solved rapidly on the analog computer.

The cam shape is first determined by integrating the acceleration curve, Fig. 5, to obtain the velocity curve. The velocity curve is then integrated to determine cam follower displacement. Results indicate that the proposed cam is unsatisfactory since it does not provide smooth load transfer, and the cam follower will not stay on the cam, Fig. 5. Several other cam shapes are evaluated rapidly until a satisfactory one is found, Fig. 6. If the designer so desires, he can obtain solutions quickly for various springs and masses.

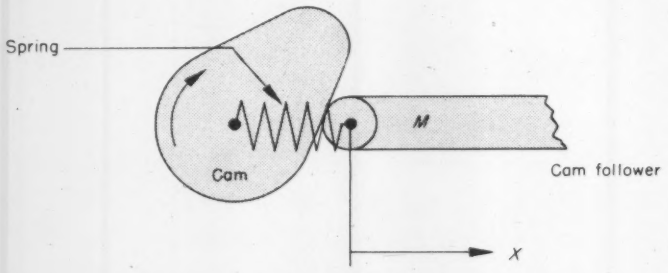


Fig. 4—Example of design problems in a typical cam and cam follower arrangement. As cam rotates, the follower is displaced in the X direction only. Problem requires a satisfactory cam shape to give smooth motion to load transfer. Computer can predict performance of proposed cam as well as evaluate alternate shapes.

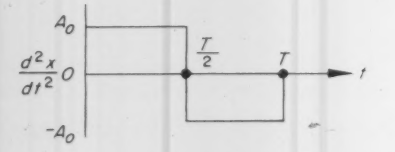
Computer solution of this design problem provided the designer with the following:

1. Proposed cam shape is unsatisfactory.
2. Several alternate cam shapes are satisfactory.
3. Performance characteristics of these alternate shapes are available.

Based on predictions of actual system performance, this information allows the designer to change the cam shape. It would have been costly and time-consuming to make such changes after the system was built. This example illustrates one of the major money-saving advantages of the computer—design evaluation before construction.

Computer Problem Types: An outstanding feature of the analog computer is its great versatility. Little time is required to obtain a series of solutions for different values of problem parameters and different functions. This feature enables the designer to explore many possible designs and hunches rapidly.

Accuracy is one of the fundamental considerations for an analog computer solution. It varies from approximately 0.1 to 10 per cent. Nearly all recent analog computers are rated between 1 and 0.1

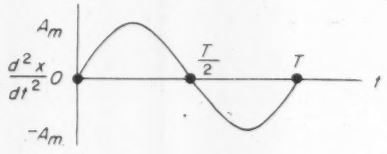


$\frac{d^2x}{dt^2} = A_0 \left(0 \le t \le \frac{T}{2}\right)$ $\frac{d^2x}{dt^2} = A_0 \left(\frac{T}{2} \le t \le T\right)$

T = Cam motion period
t = Time
A_0 = Constant acceleration

Uniform cam acceleration curve

Fig. 5—Solution of problem of Fig. 4. Graph indicates that cam acceleration curve did not provide smooth load transfer. Here, cam follower would not stay on cam shape.

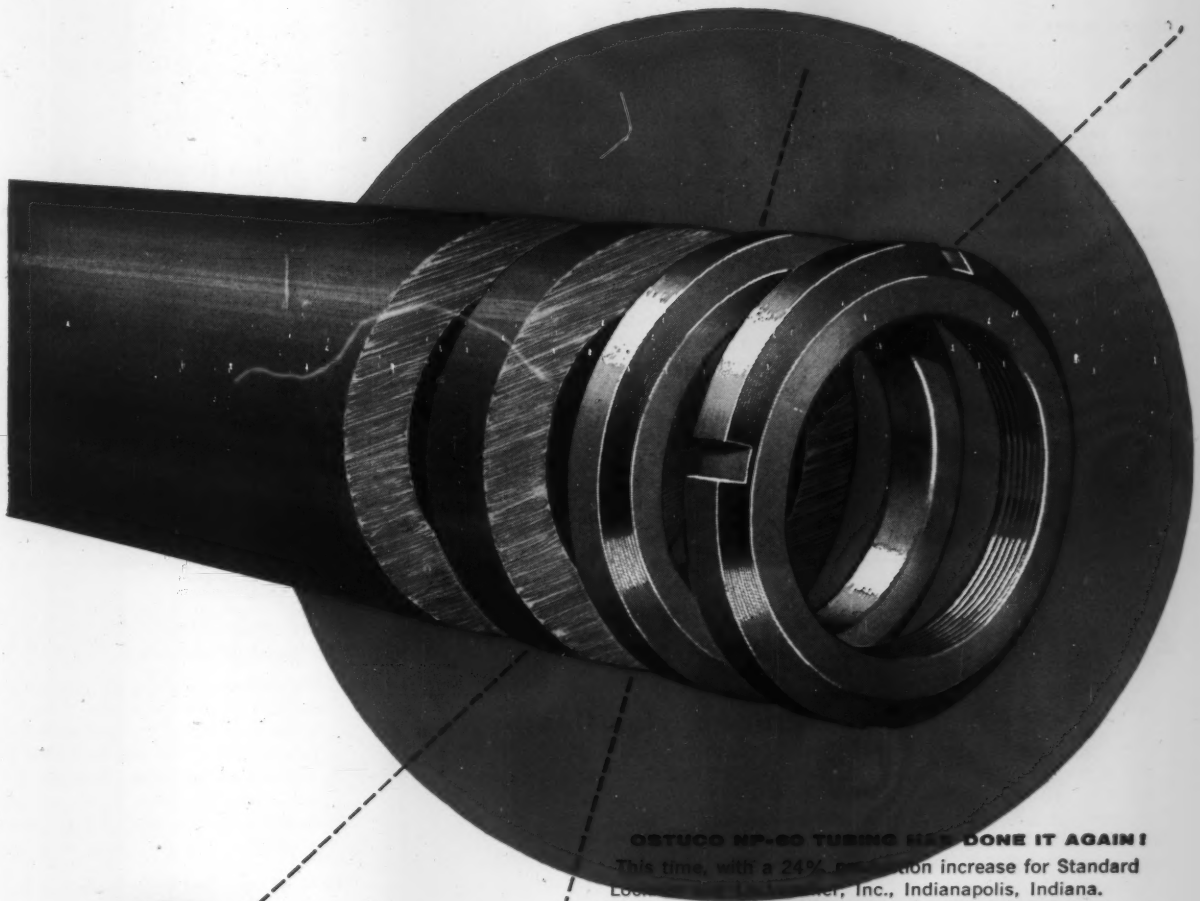


$\frac{d^2x}{dt^2} = A_m \text{ Sin } \frac{2\pi}{T} t$

T = Cam motion period
t = Time
A_m = Maximum acceleration

Sinusoidal cam acceleration curve

Fig. 6—Satisfactory cam shape as the result of computer evaluation. Here, smooth load transfer is indicated by the sinusoidal cam acceleration curve.



24% Production increase at Standard Locknut & Lockwasher, Inc. after switching to OSTUCO NP-60 tubing

OSTUCO NP-60 TUBING HAS DONE IT AGAIN!

This time, with a 24% production increase for Standard Locknut & Lockwasher, Inc., Indianapolis, Indiana. Tubing experts from OSTUCO recently recommended a switch to NP-60 Tubing specially processed for machineability for Standard's locknut and lockwasher line used in ball and roller bearing applications.

Standard components find their way into electric motors, machine tools, automotive, aircraft, farm and construction equipment. Other companies, with equally diverse applications, report similar success with NP-60. If you are machining bearings, washers, collars, or any circular part, you'll do well to check into the merits of OSTUCO's new NP-60 seamless steel tubing.

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Circle 492 on page 19

per cent accurate.

Many problems solved by computer methods are dynamic problems concerned with machines—design, load transfer calculations, vibration analysis, heat flow calculations, analysis of pneumatic and hydraulic systems, etc. Solutions of these problems depend on equations which accurately represent the physical system. A partial listing of the types of analog computer problems illustrates its diversity of application:

Mechanical Engineering

1. Design and partial system testing of control systems.
2. Production testing of control devices.
3. Vibrations of structures.
4. Spring systems and vibration absorbers.
5. Torsional vibrations in shafts.
6. Dynamics of mechanisms.
7. Flow problems.

Electrical Engineering

1. Analysis of nonlinear circuits.
2. Studies of modulation systems.
3. Studies of noise effects in communications.
4. Electron optics.
5. Feedback amplifiers and automatic controls.
6. Analysis of transmission lines.
7. Servomechanism analysis.

Chemical Engineering

1. Design of process controls.
2. Continuous process analysis.
3. Nuclear chemistry studies.

Research and Economics

1. Evaluating plant efficiency.
2. Economic distribution of power to loads.
3. Linear programming problems.

REFERENCE

1. J. Roedel—*An Introduction to Analog Computers: a Palimpsest on the Electronic Analog Art*, G. A. Philbrick Researchers Inc., Boston, 1955, Page 35.

From "Application of the Analog Computer to Engineering Problems," in General Motors Engineering Journal, *April-May-June*, 1957.

Electrical Insulation Materials

for high-temperature application

By B. J. Mulvey

Application Engineer
General Electric Co.
Bridgeport, Conn.

MANY special wire and cable applications involve high-temperature operation. In general, this means that for normal cable life, a heat-resistant cable insulation must be used in any application where ambient temperatures run higher than about 50 C (122 F).

Depending on construction and application details, asbestos-insulated cables can be used at conductor temperatures up to 200 C (392 F). However, such cables are vulnerable to moisture absorption which can occur during either light-load or shutdown periods. Varnished cloth tapes inserted between layers of asbestos furnish some moisture resistance. A lead sheath over asbestos-varnished cambric insulation offers the most reliable moisture resistance but limits cable use to a maximum conductor temperature of 110 C (230 F).

Besides poor moisture resistance, the electrical properties of asbestos also severely limit its use. Its insulation resistance is extremely low compared with almost any other insulation. The very high power factor and dielectric constant lead to excessive internal losses in the insulation wall on high-voltage applications. For this reason, the material has been generally limited to 600-v applications, with some at 5000 v.

Glass yarns have been used in high-temperature cable design but principally as outer braids for mechanical protection of the primary insulation. The type of impregnant or varnish treatment given glass yarns primarily determines their insulating properties. Glass itself is generally regarded as a spacer rather than an electric insulator. A mineral-insulated cable, Type MI, consists of one or more solid-copper conductors embedded in closely packed magnesium-oxide insulation and enclosed within a solid-copper tube. Its excellent heat and flame resistance and the inert properties of the refractory magnesium-oxide insulation have made this cable useful in areas subject to severe nuclear radiation. This cable presents three main problems:

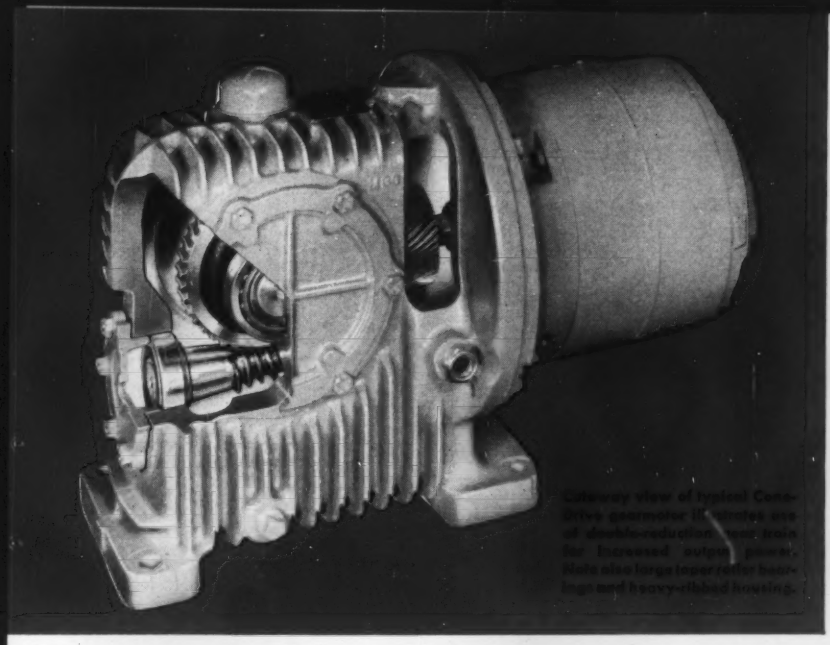
1. Hygroscopic nature of the magnesium oxide requires special moisture seal terminal fittings.
2. Length of cable and number of conductors per cable that can be made are limited.
3. It is restricted for 600-v circuits or less.

Insulation Requirements: Ideal insulation for high-temperature cables should be:

1. Suitable for high-temperature and flexible at low temperatures.
2. Stable electrically over a wide temperature range.
3. Low in power factor and specific inductive capacity.
4. Physically strong enough for fabrication and installation.
5. Weather, fungus, moisture, and corona-resistant.

Silicone Insulation: Some silicone-rubber compounds can, with sufficient care, be extruded on copper conductors. However, in comparing the physical and electrical properties of extruded silicone rubber with commonly used rubber-like insulations, silicone rubber has low tensile strength, Table 1. This makes it difficult to extrude heavy walls and limits the cables to a maximum conductor size of 500,000 cir mils (MCM) and a maximum wall thickness of 0.1719-in. for 5000-v cable.

The main attraction in silicone rubber is its heat resistance. In a test of silicone rubber versus or-



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Flexibility! You can select Cone-Drive gearmotors with extended shaft or for shaft mounting. Both are standard. Shaft mounting often permits "hanging" the driven load on the gearmotor to eliminate pillow blocks, bearings, torque arms, shafts, pulleys, bed plates, etc. Both types may be floor, wall or ceiling mounted as desired.

Why 27 standard output speeds?
Standardization! Standard reductions range from 3.3:1 to 240:1. Speeds at 1750 rpm input range from 525 rpm to 7.3 rpm output speed. Any variation in input speed will naturally provide another complete set of 27 output speeds. Any standard type NEMA D-flange motor may be used. Other reductions may be obtained on special order at additional cost.

Why ratings to only 25 horsepower?
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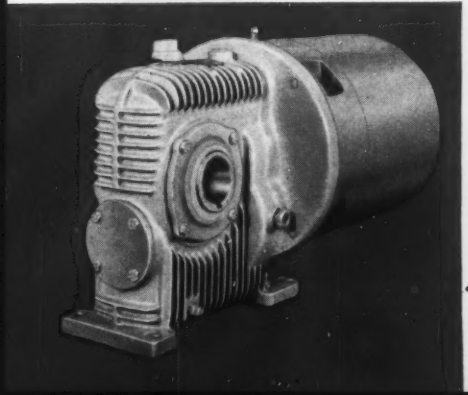

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Table 1—Properties of Electric Insulation Materials

Properties	Silicone Rubber	Natural Rubber	GR-S	Neoprene	Butyl	Polyvinyl Chloride	Polyethylene
Maximum operating temperature, deg C	150-200	75	75	90	90	80-105	75
Physical Properties							
Elongation, per cent	100-300	500	500	750	550	150	500
Tensile strength, psi	500-1000	2000	1000	1800	700	2500	1500
Low temperature flexibility	Excellent	Very good	Good	Good	Very good	Fair-very good	Excellent
Abrasion resistance	Poor	Fair	Fair	Good	Fair	Very good	Good
Ozone resistance	Excellent	Poor	Poor	Very good	Very good	Very good	Good
Tear resistance	Poor	Fair	Fair	Fair	Fair	Very good	Very good
Flammability	Burns (leaves nonconducting ash)	Burns	Burns	Nonflammable	Burns	Nonflammable	Burns
Specific gravity	1.2	1.60	1.40	1.60	1.40	1.35	0.92
Electrical Properties							
Insulation resistance, kilo-ohms	5000	20,000	2000	100	75,000	2000	75,000
Dielectric strength, v/mil	450	450	450	400	450	750	1000
Power factor	0.0050	0.0400	0.0350	High	0.0100	0.1000	0.00050
Dielectric constant	3.1	5.0	4.2	High	4.0	6.0	2.3
Chemical Resistance							
General	Good	Fair	Fair	Good	Good	Very good	Very good
Strong bases	Good	Fair	Fair	Good	Good	Very good	Very good
Strong acids	Poor-fair	Fair	Fair	Good	Very good	Very good	Very good
Oil and gasoline	Poor-good	Poor	Poor	Good	Fair	Very good	Very good
Moisture absorption	Very good	Fair-good	Excellent	Fair	Very good	Very good	Excellent

ganic rubber at 400 F in air, organic rubber practically disintegrated after an 8-hour exposure while silicone rubber after a 60-day exposure had stabilized, with its physical properties only slightly below their original values.

Moisture resistance is an important consideration in choosing a cable insulation. Compared with an acceptable value of up to 20 mg, the Underwriters' Laboratory report on silicone-rubber appliance wire shows a test value of 4.5-mg water absorption per square inch of exposed surface.

High-Temperature Application: Silicone extruded-rubber insulated cables are increasingly used in hot locations where conventional rubber or asbestos cables have given trouble.

As the cost of silicone rubber decreases, its use will increase to the extent that it will probably replace asbestos-varnished cambric as a general-purpose high-temperature cable insulation. Silicone-rubber insulated cable fits the trend toward Class H equipment for use in prolonged high temperature or occasional overloading.

From "New Trends in High Temperature Cable" in General Electric Review, *Vol.* 60, *No.* 2.

Aluminum in Electrical Systems and Coil Design

By T. E. Lewis and J. C. Meekins

Product Development Group
Reynolds Metals Co.
Louisville, Ky.

ALUMINUM wire and covered conductors have been used in the past in times of extreme copper shortages. They have not found wide usage because of the increased volume normally required. This increase in volume would require the redesign of structures and, in general, make direct substitution impractical.

Conductor Price Trends: The relatively steady base price of aluminum over the past 20 years is shown in Fig. 1. A comparison of copper and aluminum as electrical conductors will demonstrate aluminum's natural cost advantage. The electrical conductivity of EC grade aluminum is only 61 per cent that of an equal volume of copper. However, because the density of aluminum is about 30 per cent of copper, for equal conductivity only 0.485 lb of aluminum are needed to replace 1 lb of copper.

It has been difficult in the past to take advantage of this gap between base prices.

Interleaved Strip Conductors: An examination of the cross-section of a typical magnet wire wound coil shows many void spaces. The interleaved strip conductor coil eliminates these voids and provides the

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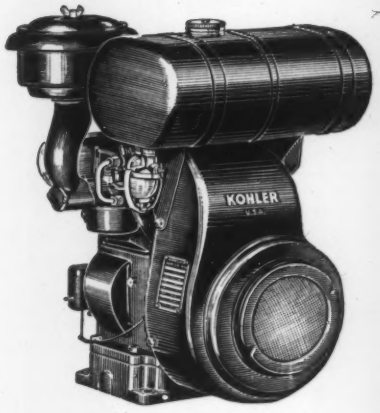

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Circle 494 on page 19

following superior features in coil design:

1. Space factors of 80 to 90 per cent are obtained and although 60 per cent more conductor volume is required, the coil can be wound into the space required for copper wire coils.
2. Since there is only one layer, layer to layer voltages are reduced.
3. Interleaved strip conductor coils are easy to wind. High-speed equipment can be used.
4. Heat transfer characteristics are better, and coil hot spots are virtually eliminated. Lower average operating temperatures are obtained.
5. Impregnation of coil is unnecessary and can be eliminated to reduce costs.
6. Advantage can be taken of the low base price of aluminum with significant cost reductions.

Conductor Cost Savings: Conductor cost savings of up to 50 per cent are possible with interleaved strip conductor. Equivalent wire gage can be achieved by varying either strip width or thickness. In general, the higher the strip thickness, the higher the space factor and the higher the conductor cost savings.

Application to Coils: Interleaved strip conductor has proven very satisfactory in many electrical coils. Examples are field coils for generator and motor starters, starter relay coils, voltage regulator coils and ignition coils. Tests have proven that using wide thin foil results in greatly improved heat transfer characteristics. In addition to the lower average temperature rise, hot spots are virtually eliminated. Hot-spot temperatures limit current density in a coil and current density determines the amount of conductor necessary for a winding.

The series coil uses fairly large flattened wire with thin insulation and generally takes more space than a similarly wound copper coil, but the interleaved shunt field offers the high space factor and cost advantages of other interleaved strip-wound coils. The series winding does offer significant cost savings but must be fitted into the space available.

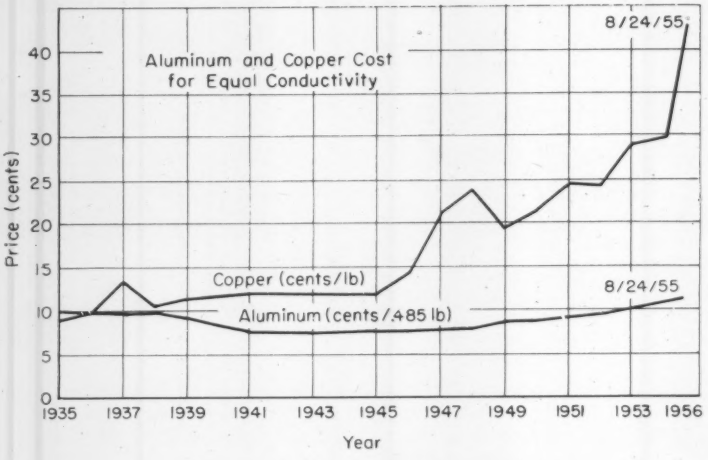

Fig. 1—Price per pound of copper compared to the price per 0.485 lb of aluminum. Figures are based on relative conductivities of the two metals.

Winding Interleaved Strip Conductor: A magnet wire wound coil consists of many layers and many turns per layer. As an example, assume the problem of winding twenty ½-in. wide coils. While twenty payoff reels are required for winding magnet wire, two are sufficient for interleaved strip—one each for foil and interleaving insulation. A 10-in. wide roll with individual slitters for each coil will accommodate the twenty coils being wound. Savings are reflected in:

1. Reduced floor space.
2. Reduced reel inventory.
3. Reduced conductor inventory. One gage of foil in various widths represents several wire gages.
4. Lower rejection rates and simpler insulation system.
5. Simpler, less costly winding equipment.

Joining: Recent developments have demonstrated that very effective and economical methods of joining aluminum are now available. Some of the more interesting of these are:

1. Coldwelding: Pressure welding at room temperature has become very useful in making aluminum joints. Joints formed by this method give high conductivity and high strength, and are unaffected by life or temperature cycling.
2. Shielded Inert Arc Welding: This method is well-known and is useful for many types of aluminum joints.
3. High-Temperature Solder: A new development in soldering makes use of the abrasive properties of a fiber glass brush. No corrosive flux is necessary since the brush pretins the surface.
4. Mechanical joints have been made which give good conductivity and long life. Proper care is necessary in their design, but results show that they are very practical.

Applications: Solenoid contact surfaces appear to be excellent applications for interleaved strip conductor, and a whole new opportunity is visualized in the field of wiring harnesses. Recent developments in printed circuits with plug-in harness connections have been very effective. These should evolve further into the widespread use of printed circuit board using aluminum and other readily automated techniques such as aluminum strip conductor wiring harnesses.

From a paper entitled "The Effective Utilization of Aluminum in Automotive Electrical Systems" presented at the SAE National Passenger Car, Body and Materials Meeting, in Detroit, March, 1957.

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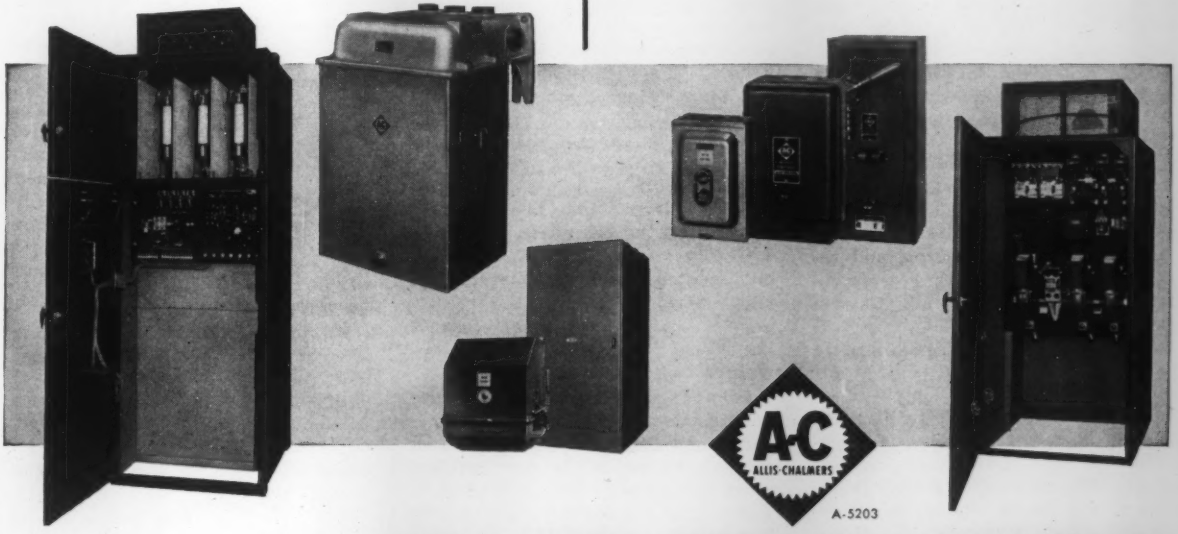

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Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Rectifiers & Capacitors

General information on rectifiers and capacitors is found in pages of ReCap, a new every-other-month journal. Typical issue contains basic data, application information and answers to questions. Company will put those interested on mailing list. Fansteel Metallurgical Corp., Rectifier-Capacitor Div.

Circle 651 on page 19

Variable Transformers

Expressly designed for high frequency service such as is encountered in aircraft, marine, missile and industrial use, new line of Powerstat variable transformers is described in bulletin P257H. They deliver continuously adjustable voltage from 400/800 cycle ac power lines for up to 480-v service in ratings from 56 va to 8.7 kva. 28 pages. Superior Electric Co.

Circle 652 on page 19

Drafting & Reference Table

An adjustable drafting table for one man and a reference area for the next man in line are combined in the Stacor-Matic drafting unit. Toe-touch foot control adjusts table height from 37¾ to 45½ in. and angle from horizontal to vertical. Details are given in folder 554. 6 pages. Stacor Equipment Co.

Circle 653 on page 19

Motor Ordering Sheets

AWH MS101 and AWH MS102 application data sheets aid in ordering or requesting information on motors and elapsed time indicators, and repeat cycle timers and time delay relays, respectively. A. W. Haydon Co.

Circle 654 on page 19

High Strength Steel

"Design Manual for High Strength Steels" discusses the essential principles of structural design and includes formulas, charts and tables which will assist engineers in designing for high-strength steels. Major divisions cover tension, shear, stresses in beams, deformation and deflection, formed sections and designing against corrosion. Beam formulas appear in the appendix section. 170 pages. United States Steel Corp.

Circle 655 on page 19

Nylon Coil Bobbins

One-piece nylon coil bobbins specified in bulletin range in core diameters from 0.220 to 0.365-in. The data sheet shows variations available without incurring tool costs. 1 page. Gries Reproducer Corp.

Circle 656 on page 19

Test Equipment

New edition of catalog "Microwave and UHF Electronic Test Equipment" covers such recent additions as UHF frequency meter detectors, coaxial detectors, broadband disk bolometers and thermistors, coaxial turret attenuators and wave and power meters. Line includes waveguide and radar test equipment. 48 pages. Narda Corp.

Circle 657 on page 19

Flexible Hose & Duct

Prices and other pertinent data relative to Flexaust flexible exhaust hose and Portovent retractable duct are given in bulletin 70. Such accessories as screw couplings and cuffs, flanges, Y's, transitions, reducers and branches are covered. 8 pages. Flexaust Co.

Circle 658 on page 19

Electric Clips

Every electric clip in this company's line is described and illustrated in catalog 200. Emphasis is on alligator-type and miniature test clips. 8 pages. Mueller Electric Co.

Circle 659 on page 19

Relays

Printed circuit relays, miniature and subminiature, six-pole double-throw and power relays, snap-action relays, 400-cps relays and rectified units are among items described in engineering catalog 157. Units with hermetically sealed and dust-tight enclosures are shown. 16 pages. Magnecraft Electric Co.

Circle 660 on page 19

Miniature Panel Meter

Engineering information, specifications, electrical characteristics and ranges relative to model 155 1½-in. flush mounting panel meter are provided in data sheet 268. Meter is intended for portable, airborne and similar uses where small size and light weight are essential. 2 pages. International Instruments Inc.

Circle 661 on page 19

Controlled Volume Pumps

Precise metering and pumping of corrosive liquids against pressure is function of line of motor-driven controlled volume pumps described in bulletin 553-1. Pumps are used as final control elements in proportioning and control systems for blending and formulating. 32 pages. Milton Roy Co.

Circle 662 on page 19

Bimetal Thermostats

Stemco bimetal thermostats are illustrated, and information on temperature ranges, ratings, mountings and terminal arrangements is given in bulletin 8400. A handy temperature conversion chart is provided. 4 pages. Stevens Mfg. Co.

Circle 663 on page 19

Floating Gearmotor

Features are pointed up in folder B-6370 on a floating gearmotor drive unit designed to meet severe operating conditions and space limitations of runout tables and similar roll-type conveyors. 4 pages. Westinghouse Electric Corp.

Circle 664 on page 19

Conveyor Belt

Flexibility of solid woven belting is combined with high strength and low elongation characteristics of stitched canvas in Main/Rusco S.C.-18 conveyor belting described in bulletin R18507. Belt is engineered for small diameter pulleys. 4 pages. Russell Mfg. Co.

Circle 665 on page 19

Optical Analysis of Gears

"Optical Analysis of Gears and Splines" is title of comparator en-

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Circle 496 on page 19

gineering study on an optical system for inspection and analysis of fine pitch involutes. With this method, a single master chart is used to inspect a wide range of gear sizes. 12 pages. Jones & Lamson Machine Co.

Circle 666 on page 19

Plastic Coatings

Unusual 17 x 25 in. wall chart lists a wide variety of liquid plastic protective coatings for architectural, industrial and marine application. Industrial section includes coatings for metal tanks and pipes, steel structures, machinery, trucks, manufactured articles, containers and railroad cars. Protective Coatings, Inc.

Circle 667 on page 19

Commercial Glass

Revised bulletin B-83 on properties of selected commercial glasses covers such new glasses as aluminosilicate glass, low loss iron sealing glass, fused silica and radiotron tube and capacitor glass. Mechanical, thermal, electrical and chemical properties are discussed. 16 pages. Corning Glass Works.

Circle 668 on page 19

Laminated Disk Filters

Information on design, construction, specifications and capacities of standard, high pressure and duplex models of laminated fiber disk filters is provided in bulletin 7C. Filters remove solid particles as small as 2 microns. 16 pages. Wm. W. Nugent & Co.

Circle 669 on page 19

Air & Hydraulic Valves

Quick-As-Wink air and hydraulic control valves in sliding sleeve, single plunger, O and B-type and high pressure hydraulic models are pictured and described in bulletin 571. Hydraulic pressure ratings range up to 5000 psi. Valve and hose couplings are also covered. 12 pages. C. B. Hunt & Son, Inc.

Circle 670 on page 19

Pipe, Tubing & Fittings

Equipment requiring pipe, tube and welding fittings to handle fluids at elevated pressures and temperatures can make use of Croloy 1¼ and Croloy 2¼ chromium molybdenum steels, described in technical bulletins 152-A and 145-A. Analyses, properties, fabrication, heat treatment and other data are included. 4 pages each. Babcock & Wilcox Co., Tubular Products Div.

Circle 671 on page 19

Reinforced Plastics

Catalog and price list of materials for glass fiber reinforced plastics includes glass fiber fabrics and fibers, polyester and epoxy resins and catalysts, and other supplies. Mats, rovings, chopped strands, hardeners, diluents and other products are described. 16 pages. Cadillac Plastic & Chemical Co.

Circle 672 on page 19

Chain, Sprockets, Buckets

Tables to aid in selecting the right chain, buckets, sprockets, bucket spacing, hand shaft wheel diameter and rpm are included in bulletin 5766 on products for cement mill service. Gravity take-ups, bearings and drag chains are described and illustrated. 24 pages. Chain Belt Co.

Circle 673 on page 19

Screw Locking Insert

Screw-Lock inserts lock screws in tapped holes. Selection tables with thread sizes, insert numbers and sizes and information on drilling, tapping, gaging and installation are found in illustrated bulletin 738. 8 pages. Heli-Coil Corp.

Circle 674 on page 19

Power Connectors

Battery, power and heavy duty connectors for many industrial uses are subject of illustrated catalog GB6. Specifications and dimensional drawings are included for each unit. 32 pages. Cannon Electric Co.

Circle 675 on page 19

Stainless Steel

Over 20 tables in booklet SS-38 on stainless steel sheet and strip present detailed data on corrosion resistance, fabrication properties, and weight per lineal foot in various widths and gages. Selection data and an industry index of applications are included. 32 pages. Allegheny Ludlum Steel Corp.

Circle 676 on page 19

Motors & Drives

"The Moving Force of Industry" is an illustrated bulletin on a line of alternating and direct current motors, gearmotors, motor-generator sets, motor controls and packaged mechanical and electronic adjustable speed drives made by Reliance and its Reeves Pulley Div. Bulletin A-2501 has 8 pages. Reliance Electric & Engineering Co.

Circle 677 on page 19

Automatic Filters

Dual purpose automatic filter with interchangeable filter elements is available with elements for lubricating oils and similar liquids, and coolants. Technical details of both types are presented in bulletin 822-823. 4 pages. Bowser, Inc.

Circle 678 on page 19

Control Centers

Information on Square D control centers and how to plan and write specifications for them is presented in illustrated manual SM 244. Various types available, design features, selector charts and steps in planning are outlined, 16 pages. Square D Co.

Circle 679 on page 19

Leaded Steels

Basic characteristics, mechanical properties and workability of leaded steel are covered in illustrated booklet. Advantages include free machining, fast feeds and speed and built-in lubrication. Several case histories are presented. 16 pages. Copperweld Steel Co., Steel Div.

Circle 680 on page 19

Forged Steel Connections

Easily installed Couplets, or branch connections for tanks, pressure vessels and pipelines are described in illustrated bulletin CP-1-57. Dimensional data and specifications on screw-end and socket-welding types on 90-degree connection are given. 4 pages. H. K. Porter Co., W-S Fittings Div.

Circle 681 on page 19

Chemical Resistant Sheet

Detailed information on Saraloy 898, a chemical resistant flexible thermoplastic sheet for lining of storage and processing tanks, medium to large diameter pipes and fittings, fume ducts and hoods is presented in illustrated bulletin 171-77. Properties, installation data, care and repair are covered. 18 pages. Dow Chemical Co.

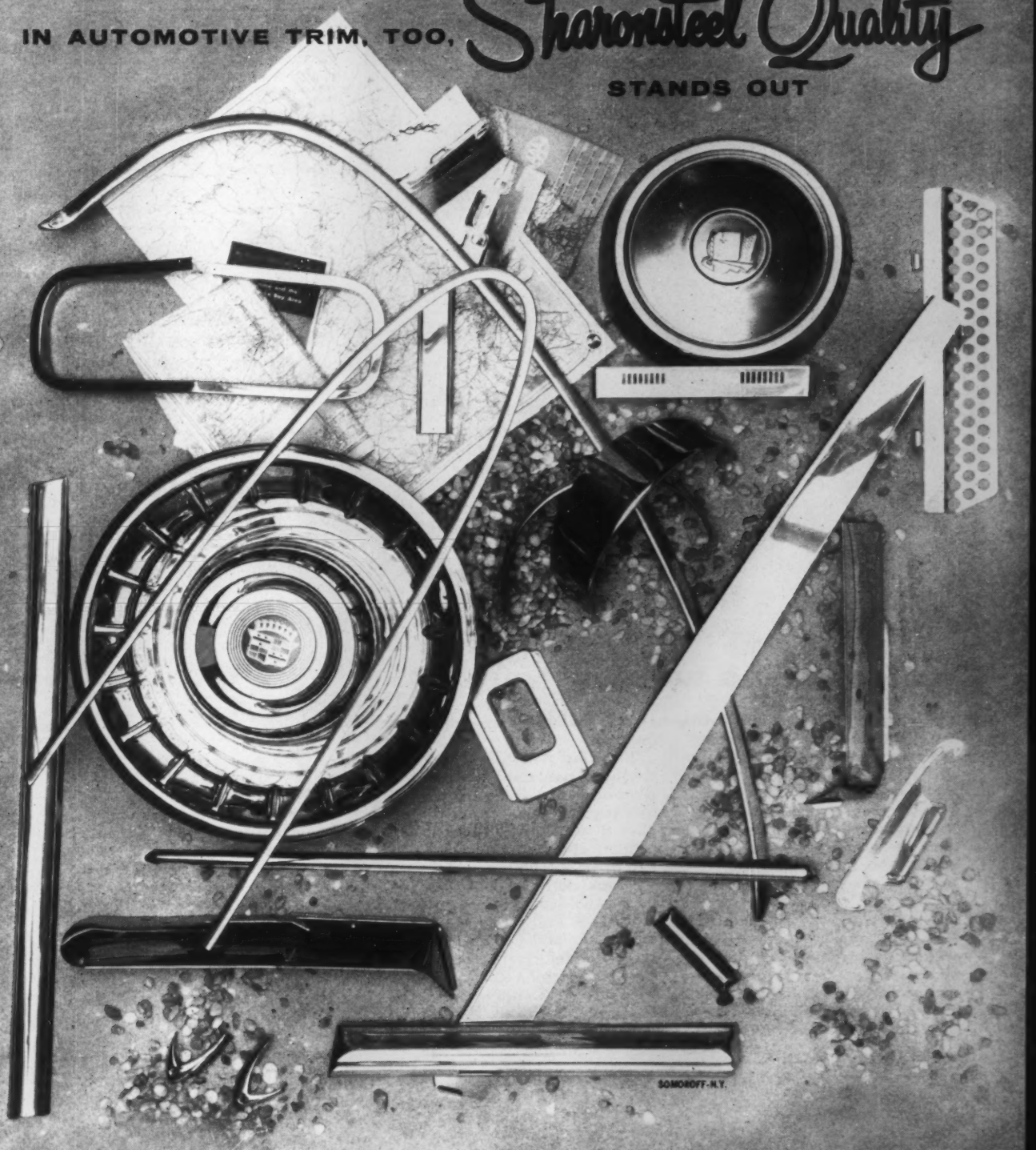
Circle 682 on page 19

Pumps

Line of recirculating and coolant pumps for sidewall mounting or im-

Circle 497 on page 19→

IN AUTOMOTIVE TRIM, TOO, **Sharonsteel Quality** STANDS OUT



Only Stainless Steel has really *lasting* beauty that defies flying stones, road chemicals, salt air, rust and corrosion season after season. Discerning automotive designers used more Sharon Stainless Steel this year than ever before for exterior and interior trim and accessories.

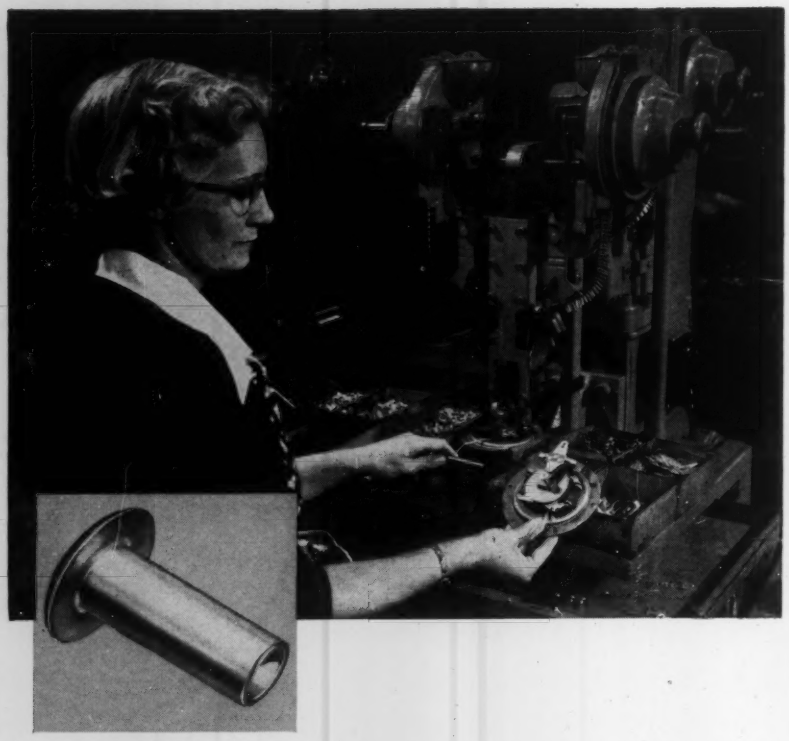
SHARONSTEEL

For 56 Years a Quality Name in Steel

SHARON STEEL CORPORATION, SHARON, PENNA.

176

CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SEATTLE, MONTREAL, TORONTO



Automatic fastening is quick and economical with Townsend tubular rivets

You reduce material and unit costs, get quick, secure fastening of metals, plastics and fabrics with Townsend tubular rivets. Any degree of automation is possible, for these rivets feed smoothly in all makes of machines—they have the uniform physical properties and accurate dimensions essential to precise operations.

Townsend tubular rivets generally have a lower installed cost than any fastener—also the slight pressure required to set them prevents damage to soft or fragile material. When properly clinched they have great holding power—develop sheer strengths comparable to bulkier, more expensive fasteners.

Tubular rivets are light in weight—present an attractive appearance—add decorative appeal to many products. Townsend supplies these rivets in steel, brass, copper, aluminum, nickel-silver, and other special materials.

Quick delivery is assured by large stocks maintained in New Brighton, Pa.; Chicago; Santa Ana, Cal.; and Gananoque, Ontario. For information on how to increase fastening efficiency, write for Bulletin TL-103 to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Helpful Literature

mersion installations is subject of illustrated catalog 7444. Motorpumps range from ¼ to 10 hp and deliver up to 500 gpm at heads to 160 ft. 4 pages. Ingersoll-Rand Co.

Circle 683 on page 19

Steel Tubing & Pipe

Data chart explains tolerances for both seamless and welded mechanical tubing and seamless and welded stainless steel tubing and pipe. Permissible variations are given. 2 pages. Peter A. Frasse & Co.

Circle 684 on page 19

Centrifugal Castings

Examples of products made from centrifugal castings in various alloys are given in illustrated bulletin 100. They can be up to 33 ft long, 7 to 44 in. OD, light or heavy walled and in any section or segment. Properties of available ferrous and nonferrous alloys are given. 12 pages. Sandusky Foundry & Machine Co.

Circle 685 on page 19

Process Control Instruments

Pilot controllers, transmitters, receivers and recording controllers are pneumatic process control instruments described and illustrated in catalog 505. Specifications of all units are given, along with application and design data. 16 pages. American Machine & Metals, Inc., United States Gauge Div.

Circle 686 on page 19

Gearmotors

Foot and shaft-mounted right angle gearmotors are described and illustrated in bulletin 193-557 which also outlines their design features. 4 pages. Sterling Electric Motors, Inc.

Circle 687 on page 19

Wiring Terminals

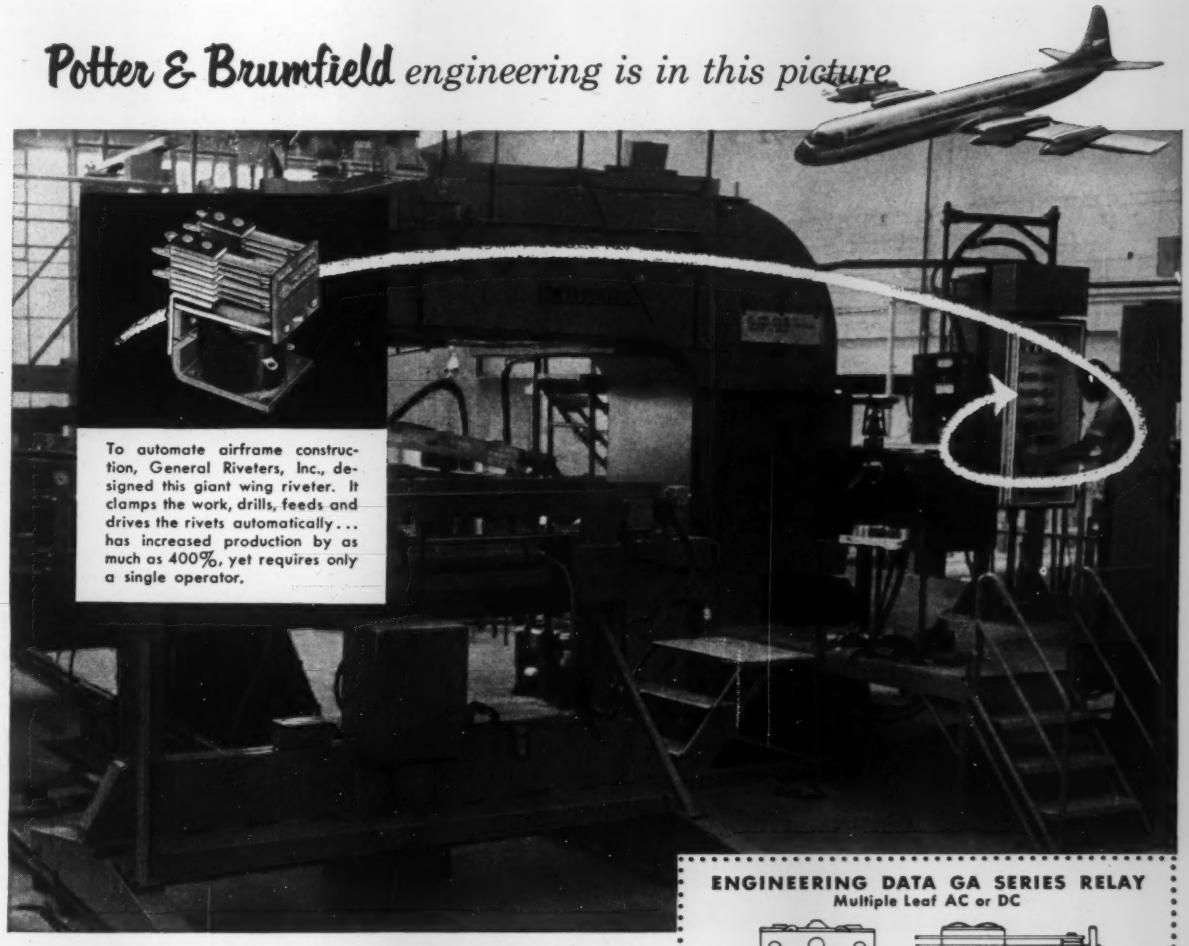
"What Goes On Here?" is an illustrated bulletin which describes connectors, terminals, splices, panels and components for OEM, electronic, appliance, aircraft and military applications. Features of each are outlined. 8 pages. Burndy Corp., Omaton Div.

Circle 688 on page 19

Vibration Testing

Five vibration test systems utilizing the new Calidyne model 177 wideband high performance vibration shaker are detailed in bulletin 17700. Equipment can be used for structural response determination, en-

Potter & Brumfield *engineering is in this picture*



To automate airframe construction, General Riveters, Inc., designed this giant wing riveter. It clamps the work, drills, feeds and drives the rivets automatically... has increased production by as much as 400%, yet requires only a single operator.

P&B RELAYS AUTOMATE THIS GIANT RIVETER *for new Lockheed Electra Wings*

This new automatic riveter will be used to make wings for the new Lockheed Electra, a prop-jet luxury liner, as well as many other modern aircraft. The heart of this riveter is a relay circuit that "takes orders" from a pattern of holes punched in 35 mm film strips.

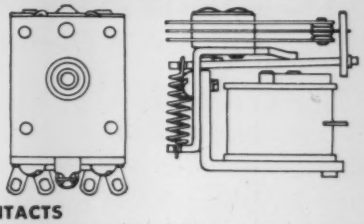
General Riveters, Inc. selected the GA Series P&B relay for the control circuits of this riveter because of its unusual dependability and versatility. In adapting this relay to a specific application, P&B's engineers again demonstrated how 25 years of creative engineering can pay off by providing a standard type or completely new relay to solve your particular problem. Write today for new compact catalog or engineering consultation.

P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

Potter & Brumfield, inc.

PRINCETON, INDIANA *Subsidiary of* AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

ENGINEERING DATA GA SERIES RELAY
Multiple Leaf AC or DC



CONTACTS
Material: 3/16" fine silver (other contact materials can be furnished for specific applications)
Rating: 5 amp. 115 V. 60c non-inductive load
Arrangements: 4 Form C Max., AC; 6 Form C Max., DC
Breakdown: 1000 V. RMS between all elements

COIL
Resistance: 30,000 ohms max.
Power req'd: 6 W. max., 2 W. min. DC at 25° C. ambient
V range: DC to 110 V.; AC to 230 V.

DIMENSIONS, MAX.
1 23/32" L. x 1 1/16" W. x 1 25/32" H.

MOUNTING DATA
4 tapped #6-32 holes, .750" x .875" o.c. 1 tapped #8-32 core

ENCLOSURES
Hermetically sealed, octal plug: 2 17/32" x 1 29/32" x 1 25/32"
Multiple solder header and miniature plug-in: 2 15/32" x 1 29/32" x 1 25/32"
Special container required for 6 Form C

TERMINALS
Contacts: two #16 AWG wires
Coil: two #20 AWG wires

See our catalog in Sweet's Product Design File

"It's round," said Chris, "perfectly round!"

Columbus proved the earth was round, just as Universal's 100% inspection proves the perfect roundness of its classic *precision* balls—quality controlled perfection for every possible application by designer and manufacturer. Both metallic and non-metallic materials are precision lapped to tolerances as fine as 0.000005 of an inch.

If it's round—perfectly round—it's a Universal Precision Ball.

UNIVERSAL QUALITY CONTROL—FOR ALL AROUND PERFECTION

Universal Ball co.

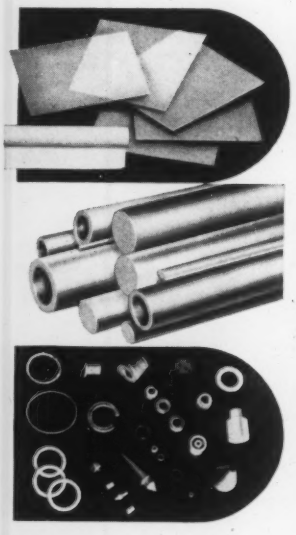
WILLOW GROVE, MONTGOMERY CO., PA.

Circle 500 on page 19

START WITH THE BEST!

Are you up to date on Fluorocarbon Stock and Parts?

SHAMBAN TEFLON*
KEL-F, CALIFILM
Tape • Sheet • Rod • Tubing • Custom Molded or Machined Parts



Exacting specifications? Meet or exceed 'em with SHAMBAN! Whatever your requirements in Teflon, Kel-F and Fluorothene—SHAMBAN *can supply them!*

Back-up Rings...O-rings...Piston rings...Scraper rings...Valve packings...Vee-seals...Tape...Spaghetti...Insulators...Film...Grommets...Glass fabrics...Fiber felt...Extruded shapes...Uncured tape...Filled Teflon ...Bondable film...Cementable sheet and tape.

Throughout industry, SHAMBAN's remarkable Qualities are pointing ways to *improve* existing products—providing opportunities to create *new* products and applications! Write, wire or phone for complete data on how SHAMBAN can help you.

**du Pont Trademark*

Use the BEST in Fluorocarbon Products, Specify SHAMBAN!

KELON

W. S. SHAMBAN & CO.

11617 W. Jefferson Blvd., Culver City, California
Meyer Road, Fort Wayne, Indiana

Circle 501 on page 19

Helpful Literature

vironmental testing and fatigue testing. Systems provide up to 5000 lb force output. 6 pages. Calidyne Co.

Circle 689 on page 19

Coolant Pumps & Accessories

The complete line of Gusher coolant pumps, portable tanks and mounting brackets is subject of illustrated general catalog. Motor, shaft and pulley driven pumps in full range of capacities are described, and design and performance data are given. 66 pages. Ruthman Machinery Co.

Circle 690 on page 19

Fluid Flow Control

"Positive Flow Control" is title of illustrated catalog 600 on line of proportioning pumps and diaphragm valves. Four pumps afford accurate proportioning of flow in range of 0 to 730 gph. Various constructions are available to handle all types of fluids including corrosive liquids, gases, air, water and slurries. 12 pages. Hills-McCanna Co.

Circle 691 on page 19

Variable Speed Belts

Features and specifications of Worthington-Goodyear variable speed V-belts as well as interchange numbers are presented in bulletin 1640-B1 P. Synthetic fiber cords add to strength and life. 8 pages. Worthington Corp.

Circle 692 on page 19

Cellular Rubber Floats

Custom fabricated to meet any need, UHR-1 unicellular hard rubber floats are suited for use in oil, fuel and other liquids. Full information is given on this fungus and corrosion resistant material in bulletins 5870 A 11 and B 1. 2 pages each. Parker Appliance Co., Rubber Products Div.

Circle 693 on page 19

Hydraulic Tubing

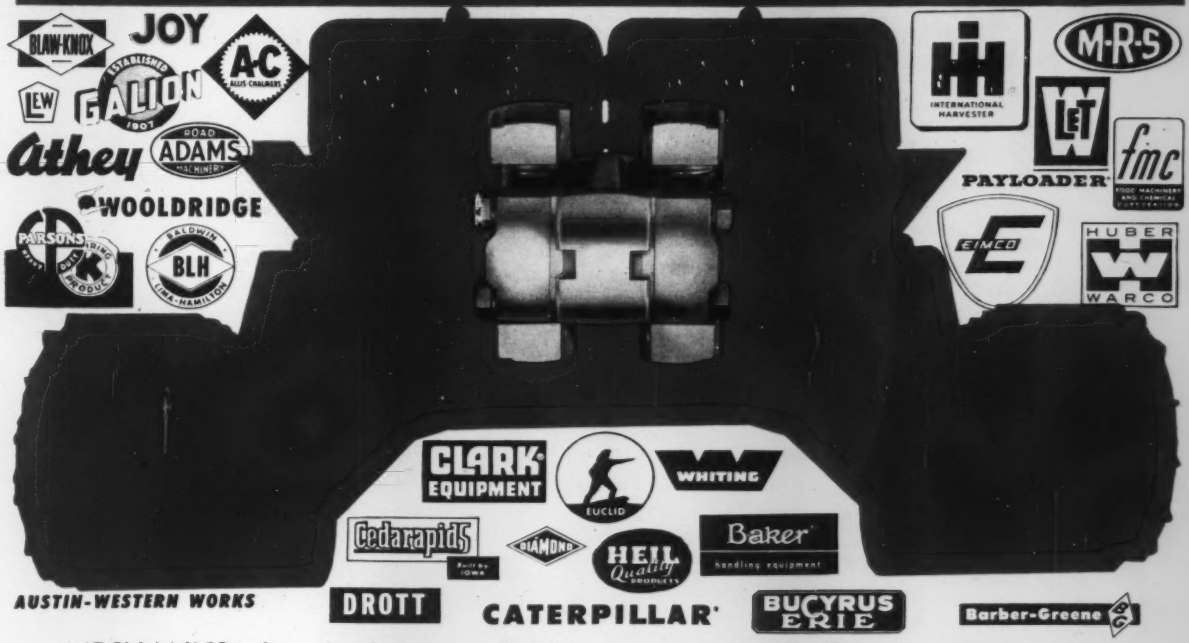
Information on mechanical, pressure, heat exchanger, condenser, hydraulic oil line, diesel fuel line, pump cylinder, precision ground and special shape tubing with the new Hydraluster bright finish is tabulated in design bulletin. 4 pages. Summerill Tubing Co.

Circle 694 on page 19

Heavy Duty Relays

Switching loads up to 15 amp at 600 v ac maximum are handled by

COMPACT



MECHANICS close-coupled type Roller Bearing UNIVERSAL JOINTS are specially designed for operation within cramped quarters, and where shafts are out of alignment — as in twin-tractor power unit silhoutted above and in rear engine cars, tractors, trucks and busses. Let our engineers show you how these MECHANICS joints will conserve space and compensate for offset shafts, in your new models. These joints fit into spaces that engineers formerly considered too short for universal joints. Our new catalog — showing complete line of MECHANICS Roller Bearing UNIVERSAL JOINTS and containing handy joint tracing kits — will be sent to manufacturers, upon request.

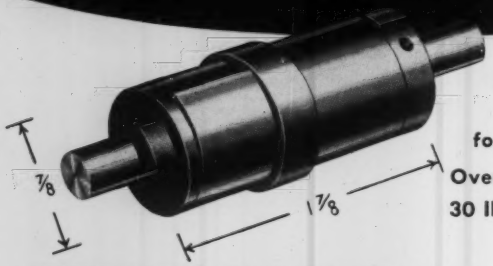
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Circle 502 on page 19

THIS Precisionspring SINGLE REVOLUTION CLUTCH can be actuated at 60 CYCLES PER SECOND!



IMMEDIATE DELIVERY
for bread-board testing

Over-runs up to 3600 r.p.m.
30 lb.-in. torque—¼" bore
Model No. SR-2

TESTED FOR 20,000,000 CYCLES

. . . with no measurable wear. There is no practical limit to the endurance of a Precisionspring Single Revolution Clutch. No loss of driving torque.

POSITIVE, ACCURATE POSITIONING

You can depend on the unfailing accuracy of these clutches.

FULL LINE OF STANDARD CLUTCHES

. . . torque capacities of 10, 30, 50, 100 and 200 lb.-in. . . . available Sept. 1. Per pound-inch of transmitted torque, they will be smaller, lighter and more compact than other clutches.

EASILY ENGAGED AND DISENGAGED

The energizing force required for engagement and disengagement is very small, which means that simple and inexpensive methods of actuation can be used.

LOW FIRST COST, LOW MAINTENANCE

In large quantities, the clutch illustrated above costs only $15.00. The first cost is the last; no lubrication or other maintenance.

MARQUETTE DIVISION
CURTISS-WRIGHT
CORPORATION • CLEVELAND 10, OHIO

Test this Remarkable Clutch!
MAIL THE COUPON

MARQUETTE DIVISION
1145 Galewood Drive, Cleveland 10, Ohio

☐ Send clutches checked below, at $51.00 each, under full warranty. Our order No._____

☐ Model No. SR-2-1—Clockwise rotation

☐ Model No. SR-2-2—Counter-clock rotation

☐ Send complete information about Precisionspring Clutches.

COMPANY_____

NAME (Please Print)_____

TITLE_____ ADDRESS_____

Helpful Literature

type IMP and FMP heavy duty relays. Design and application data are presented on plug-in and latching types with 2 to 8 poles. They are particularly suited for machine tool control. 8 pages. Arrow-Hart & Hegeman Electric Co., Industrial Control Div.

Circle 695 on page 19

Engine Transmissions

Synchronized transmissions, Step-Matic transmissions, TransVerters and torque converters ranging from 11 to 26 in. in size are detailed in "Power Transmission Equipment" catalog. Five-speed units with nominal torque ratings up to 425 lb-ft are shown. Cutaway view shows design of the torque converter. 12 pages. Clark Equipment Co., Transmission Div.

Circle 696 on page 19

Heat Resistant Castings

Properties of Thermalloy heat resistant castings which adapt them for service at high temperatures are stressed in illustrated bulletin T-225. Typical applications are shown, and design considerations are covered. 16 pages. American Brake Shoe Co., Electro-Alloys Div.

Circle 697 on page 19

Screw Pumps

Double external bearing and gear type and double external bearing and gear hopper type screw pumps in ratings up to 250 hp are described in bulletin S-206. Both jacketed and unjacketed types of pumps are available. 6-pages. Warren Pumps, Inc.

Circle 698 on page 19

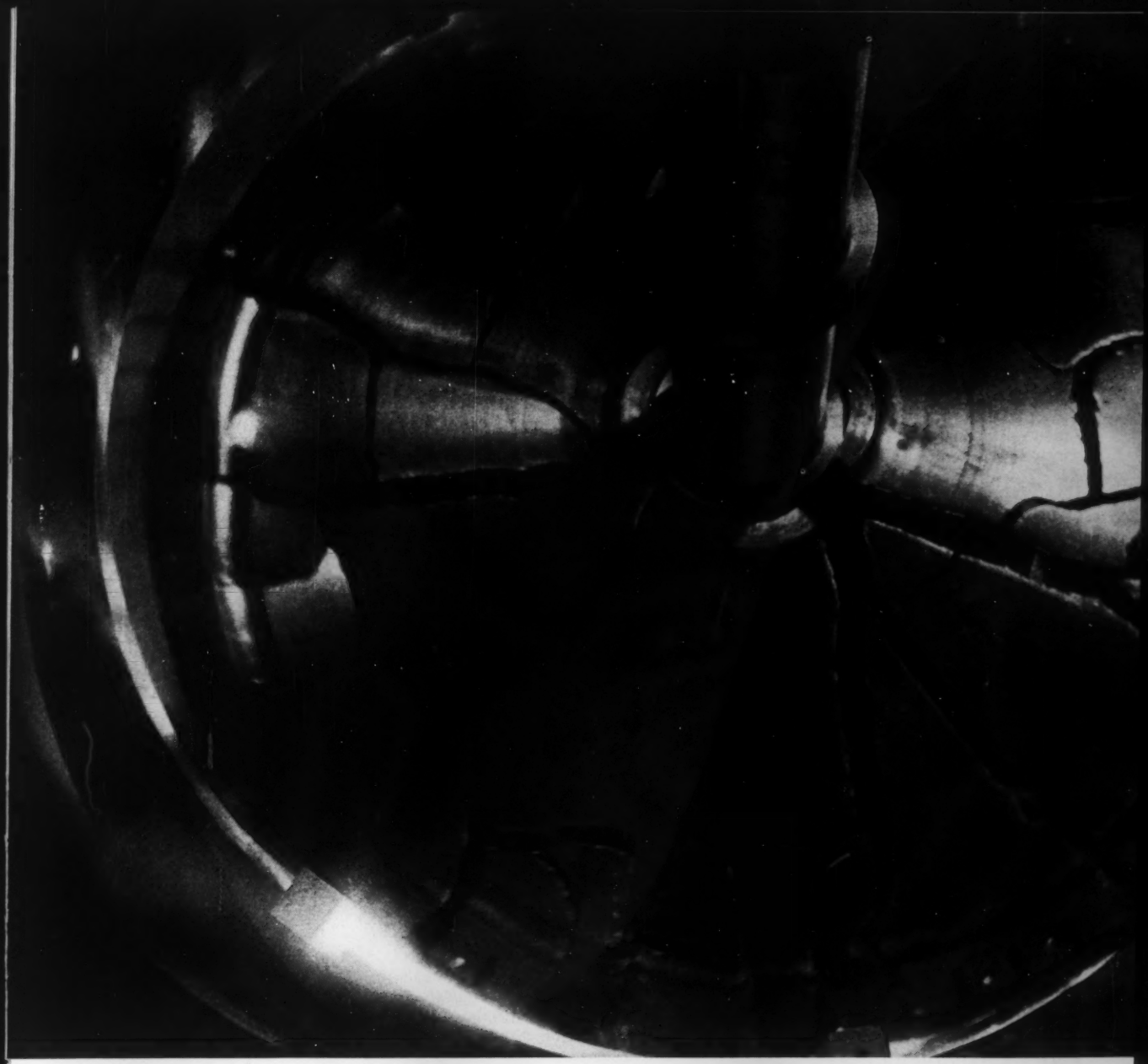
Cold Forming Steel Bars

Described as a new method for cold reduction of steel bars into multiple diameter shaft blanks ready for finish turning, the Die-Form Process is subject of illustrated folder ADV-746. 4 pages. Republic Steel Corp.

Circle 699 on page 19

Stainless & Alloy Pipe

Manual on stainless steel and high alloy pipe and tubing describes products ranging in size from ⅛ to 40 in. OD. Separate sections cover products for high pressure, aircraft, heat resistant, beverage and dairy equipment, ornaments and mechanical equipment uses, as well as shaped and formed tubing. 48 pages. Request on company letterhead from Trent Tube Co., East Troy, Wis.



This Rem-Cru titanium wheel, whirled at high speed, withstood more stress than the strongest steel.

How strong and tough is titanium?

Part of the answer is shown in a dramatic test, which may illustrate some of the characteristics you are looking for. An 18-pound jet compressor wheel of Rem-Cru C-130 AM titanium alloy was whirled at tremendous speeds. It withstood far more rpm's than the strongest steel. *In fact, this titanium wheel had to be notched before it would break at all.*

If you're looking for a strong, tough metal, with light weight and exceptional corrosion resistance, Rem-Cru titanium is the answer. It's promptly available in the grades and sizes you want.

REM-CRU TITANIUM — ***World's Most Versatile Metal***

Write Dept. MD-7 for the Rem-Cru Review—a free periodical presenting the latest data on titanium.

MIDLAND, PENNSYLVANIA

Sales Offices: 6033 East Bandini Boulevard, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.

Circle 504 on page 19

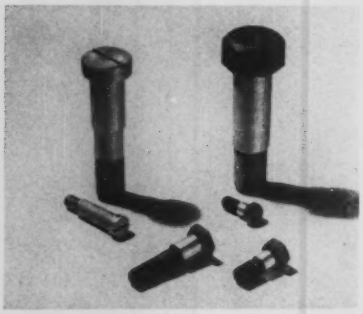
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Shoulder Screws

are upset-forged for high strength

Upset-forged shoulder screws are available in diameters to 2½ in. in any length. Unbroken and uniform grain flow of forging assures high-strength characteristics, close



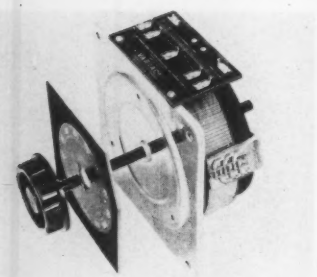
tolerances and material savings. Applications include use as axles, mounting bolts, conveyor system links, and in die sets. **Cleveland Cap Screw Co.**, 4444 Lee Rd., Cleveland 28, O.

Circle 700 on page 19

Variable Autotransformers

have increased current ratings

Type W50 Variac, shown, is available in a complete series, including 115 and 230-v models, cased and uncased units, and ganged assemblies. Rated currents are 50 and 25 amp for single 115 and 230-v models, respectively. Motor drives are available in several speeds for all units. Type W5L is for 115-v, 60-cycle applications where overvoltage is not needed. Unit controls loads up to 11 amp at line voltage, providing output-power rating of over 1¼ kva. Up to 8.5 amp may be drawn from unit at any voltage. Cased models and



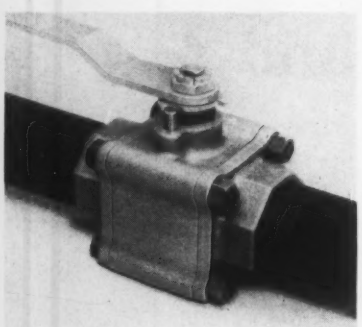
two and three-gang assemblies are also available. **General Radio Co.**, 275 Massachusetts Ave., Cambridge 39, Mass.

Circle 701 on page 19

Valve

combines union with ball valve

Installation of a separate union to provide breaking point in a line is eliminated with the use of Union-Ball valve which combines the function of a union and a ball valve in one compact unit. Resistance to flow is below that of globe or gate valve. Operation is unaffected by flow reversal, since ball is fitted with twin seals. Metal com-



ponents are bronze, aluminum bronze, or aluminum. Seat and seal materials are Buna-N, Hypalon, Neoprene, natural rubber or Teflon to accommodate a wide range of media. Components are interchangeable if fluid in system is changed. **Worcester Valve Co. Inc.**, 20 Parker St., Worcester, Mass.

Circle 702 on page 19

Electric Timer

is nuclear powered

Betachron F nuclear-powered fixed-interval time delay is a small, hermetically sealed unit with use life of over 25 years. Self-contained nuclear battery and associated circuitry provides electrical time delay from milliseconds to 40 hr with accuracy of ±3 per cent

over temperature range of −65 to 165 F. Energy output to 200,000 ergs is provided at a standard connector. Unit is suitable for time delays, alarm systems, missile and weapons systems. **Universal Winding Co.**, Patterson-Moos Div., 90-28 Van Wyck Expressway, Jamaica 18, N. Y.

Circle 703 on page 19

Hydraulic Cylinders

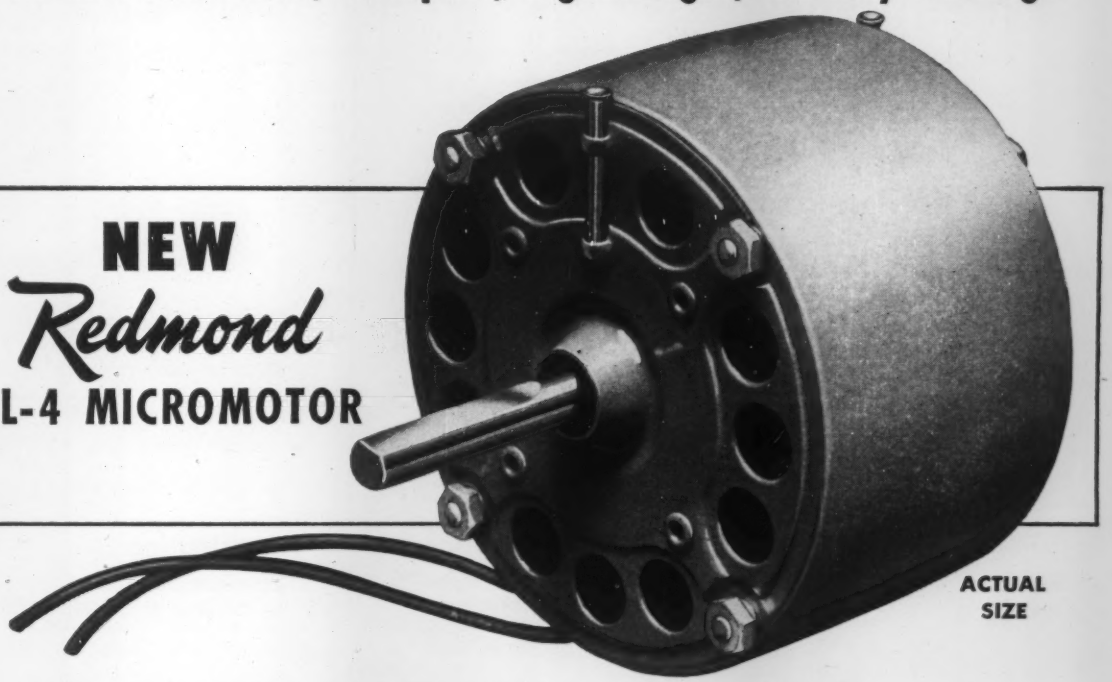
are miniature units

Hydraulic cylinders are 3000-psi, noncushioned units available in bore sizes of ½, ¾, 1, 1¼ and

MORE HORSEPOWER . . .

in an Economical, Compact, Lightweight, Quality Package

NEW
Redmond
AL-4 MICROMOTOR



ACTUAL SIZE

Designed for a Wide Variety of Applications . . . or can be Tailor-Made for Specific Requirements

Here is a motor designed and styled to meet the modern demands for motors that are smaller and lighter, and yet have increased output. It is ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and dozens of other applications.

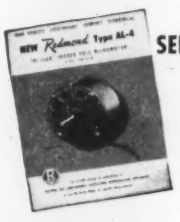
The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles, available in odd voltages and frequencies. The normal horsepower range is 1/250th to 1/15th. It incorporates two famous Redmond design features that have never before been available in a small diameter motor:

1. The patented Redmond Tri-Flux® design that greatly increases starting and running torque and improves efficiency over conventional small diameter motors;
2. The Uni-Cast® construction that gives a rigid, lightweight motor that can be manufactured to extremely close tolerances.

Because with Uni-Cast construction the stator core frame is precision die cast in one piece, the registers are machined concentric to the bore to extremely close tolerances. The exact bearing alignment and uniformity of air gap achieved with this precision manufacturing result in a motor that is whisper-quiet in operation and can be depended on to give years of trouble-free service.

Casting the stator core frame in one piece not only makes the motor most rigid, but it is light in weight, as a very durable and lightweight metal is used.

This modern motor can save money on a host of applications. If you are looking for a motor in volume quantities, send for the literature described below.



SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

ADVERTISED IN The Saturday Evening POST

The Standard of Dependability

Redmond
COMPANY, INC.
OWOSSO, MICHIGAN

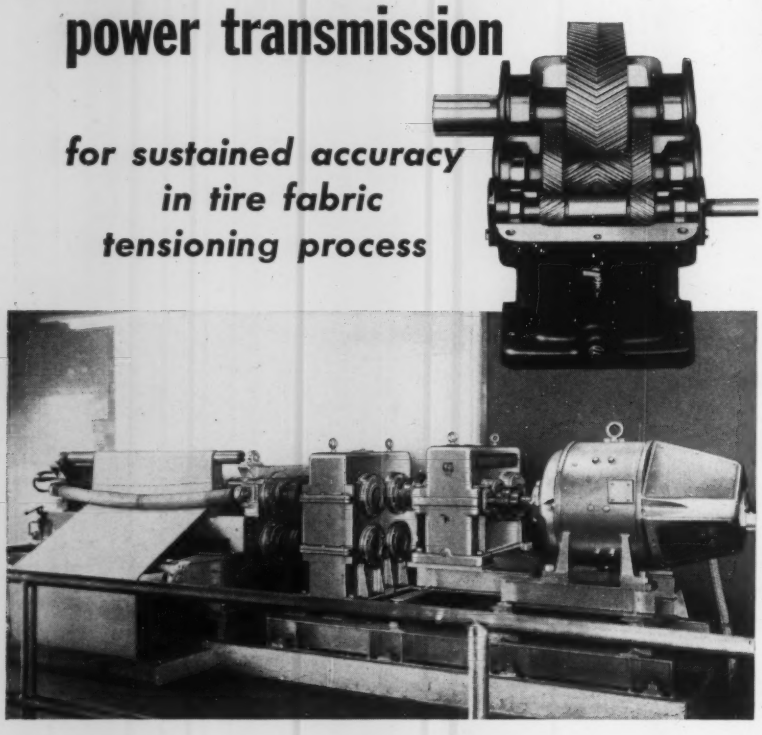
REDMOND

THE **BIG** NAME IN SMALL MOTORS

Circle 505 on page 19

Waldron selects H & S power transmission

for sustained accuracy in tire fabric tensioning process



Today's rugged, heavy-duty tires call for extra measures in manufacturing to insure dependability and longer life. An important process at Goodyear Tire and Rubber Company is this Nylon Tire Cord Unit designed and built by the John Waldron Corporation, New Brunswick, N. J. Its function is to apply tension to the basic Nylon cord fabric before it is calendered with rubber—a process that limits "growth" to an acceptable minimum when tires are in use.

Essentially a stretching process that takes place while the fabric moves at a fair rate of speed, exacting power requirements must be maintained. A double reduction herringbone H & S speed reducer was recommended by H & S engineers, to be energized by a 150 H.P. motor. Power is then distributed to the tensioning machine rolls by a special H & S four shaft roll drive.

Here's an important job for which H & S equipment is well suited. The use of anti-friction bearings throughout, generous size of shafts, gears and housings, and accurate machining to close tolerances assure long life and completely satisfactory performance. Consult your H & S representative or write us, for help in selecting Speed Reducers, Roll Drives or precision gears of many types—for dependable power transmission.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

New Parts

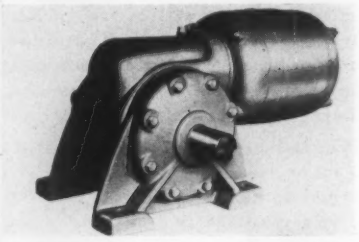
1½ in. They have low coefficient of friction seal. Rated at 3000 psi continuous service, with peaks to 10,000 psi, they are available in strokes to 36 in. **Oil-Dyne Inc.,** 2115P W. Marquette Rd., Chicago 36, Ill.

Circle 704 on page 19

Gearmotors

have ratings from ¼ through 5 hp

Right-angle gearmotors are available in all enclosures with ratings from ¼ through 5 hp. Gear case and motor housings are No. 319T6 aluminum alloy, which absorbs high torque characteristics of gearmotors, has good heat-transfer properties and is corrosion re-



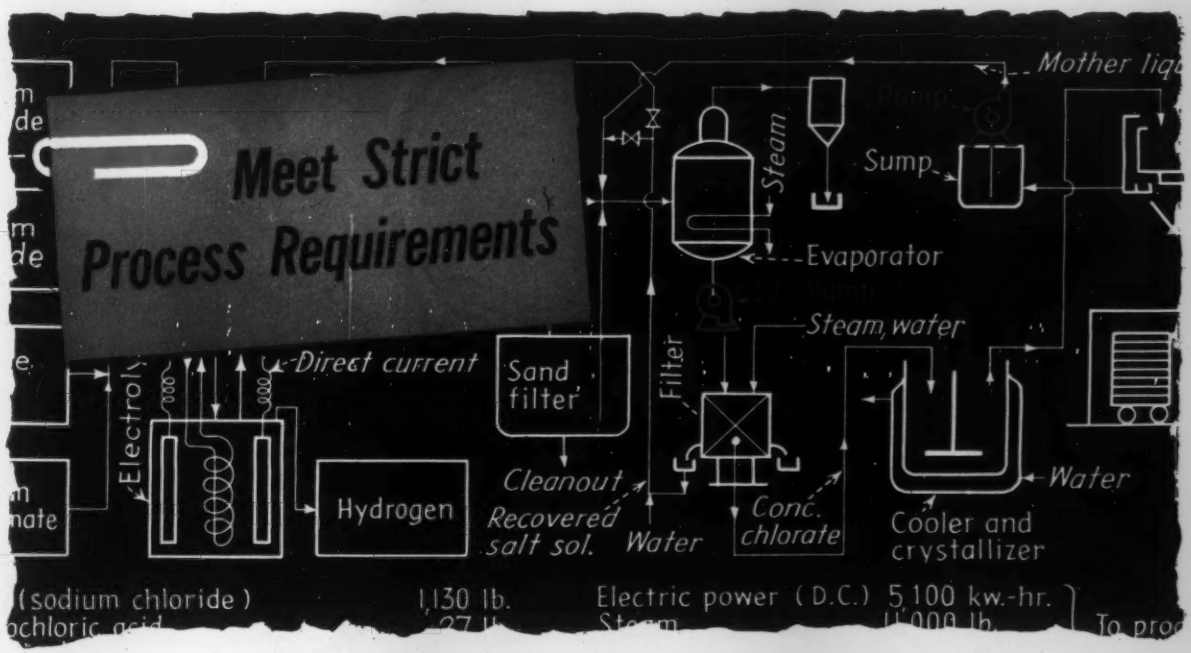
sistant. Motors are built for rugged continuous duty and meet all AGMA specifications. **Sterling Electric Motors Inc.,** 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 705 on page 19

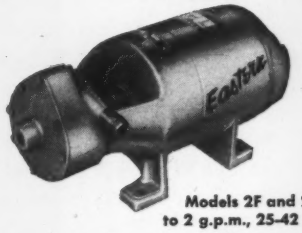
Miniature Sine Switch

withstands severe environmental conditions

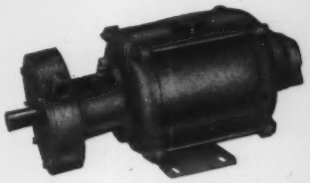
KX5 miniature switch is a high-capacity type which operates continuously at temperatures to 375 F. Sealing is accomplished with glass and fused-ceramic headers. Unit



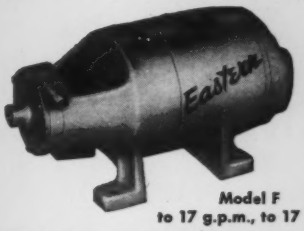
. . . with Eastern Centrifugal Pumps



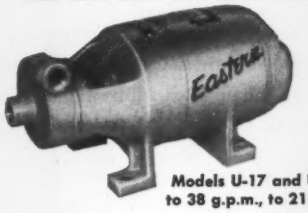
Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.



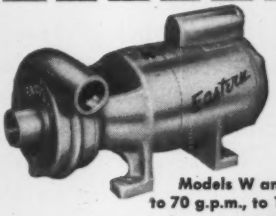
Model D-11
to 7.5 g.p.m., to 18 p.s.i.



Model F
to 17 g.p.m., to 17 p.s.i.



Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.



Models W and Z
to 70 g.p.m., to 11 p.s.i.

Models 3F and 3J
to 5 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.

NEW EASTERN CATALOG

Eastern Centrifugal Pump Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 110A.

Eastern
INDUSTRIES, INC.
100 SKIFF ST.
HAMDEN 14, CONN.

Circle 507 on page 19

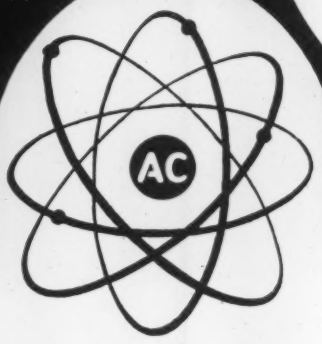
MECHANICAL ENGINEERS

DESIGN

DEVELOPMENT

PRODUCTION

Ever wanted to be a member of a real championship team?? As a member of the Product Development Engineering Department your "team play" will include:



DESIGN

You create basic design concepts based on practical means of accomplishment. Your concepts are translated by layout draftsmen to a more communicable form under your guidance. In other words, HOW, WHAT, WHY, WHERE systemized.

DEVELOPMENT

You evaluate, refine and improve; using the finest PRODUCT IMPROVEMENT TOOLS. These "TOOLS" include the best TEST and RESEARCH facilities available and you have the added advantage of working alongside the top men in this field.

PRODUCTION

You supervise the evolution of a production model based upon engineering prototypes resulting from the Design and Development. Produceability and a high degree of reliability will be your responsibility. Your job will include the maintainability and function of Electro-Mechanical Devices, Precision Gear Trains and Packaged Electronics in the fields of Inertial Guidance, Avionics and Jet Engine Fuel Controls.

Job assignments are accomplished by men operating as a team. Our program is expanding and Challenging Opportunities await qualified men for important positions on our Engineering teams. Why not you??
As a part of our Major, Permanent, Company Expansion Program, new plant facilities are being added in suburban Milwaukee.

RECENT ME GRADUATE INQUIRIES ALSO INVITED

Milwaukee offers ideal family living in a progressive, neighborly community combining cultural and shopping advantages with small town hospitality. You and your family will love Milwaukee.
To arrange personal, confidential interview in your locality send résumé today to

Mr. Cecil E. Sundeen
Supervisor of Technical Employment

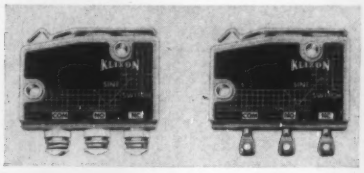
the ELECTRONICS DIVISION

GENERAL MOTORS CORP.

FLINT 2, MICHIGAN • MILWAUKEE 2, WISCONSIN

Circle 508 on page 19

is unaffected by 200-*g* shock and 40-*g* vibration at 0-500 cps. It meets envelope size of MS24456 switches. Current capacity is 10 amp at 75 F. Steel case with-



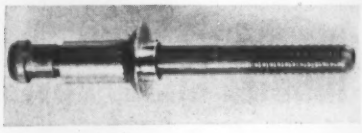
stands high impact and compression loads. Terminations are either screw or solder type. **Metals & Controls Corp.**, Spencer Thermostat Div., Forest St., Attleboro, Mass.

Circle 706 on page 19

Blind Rivets

have 1/64-in. oversize diam to fill holes

CKL blind rivets are 1/64-in. oversize on diameter to insure hole filling and to produce tight installation in dimpled sheets. They are available with countersunk head style in a variety of sizes. Pin material is 7075-T6 aluminum alloy, anodized or with chemical



surface treatment. Sleeve material is 5056-H14 aluminum alloy. Rivets are available in 1/8, 5/32 and 3/16-in. oversize sleeve diameters. **Huck Mfg. Co.**, 2480 Bellevue Ave., Detroit 7, Mich.

Circle 707 on page 19

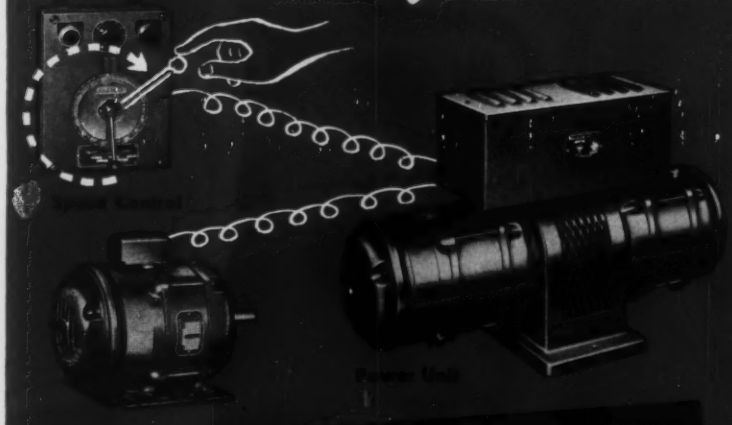
Ball Bearing

has solid inner and outer raceways

Unibal ball bearing has solid, unbroken inner and outer raceways, with full complement of balls. Radial and axial load capacities are increased because of raceway construction. Bearings are furnished in single row, double row, and flanged types. They have close tolerances on bore, outside diameter, and controlled radial and axial

(*Continued on Page* 192)

30 – STEP SPEED CONTROL
WITH A
twist of the wrist!



Baldor
ADJUSTABLE SPEED MOTOR SYSTEM

- **Easy to install...simple to service!**
- **No troublesome protective relays!**
- **No flashing contactors!**
- **No complicated electronic adjustments!**

Specially designed for machines where friction or torque is constant from high to low speed. Motor-generator set, controller and drive motor can be mounted independently, in any position.

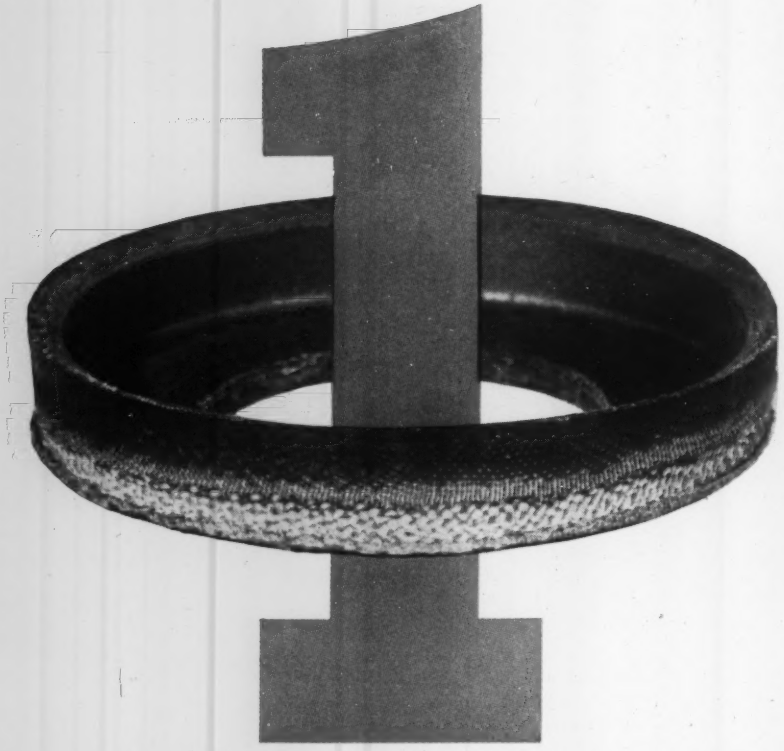
- *One* control for all adjustments. 0 to 2400 RPM in 30 steps of 80 RPM, forward or reverse.
- Totally enclosed Streamcooled construction . . . vernier rheostat for infinite speed control between steps . . . jog switch for machine adjustments . . . reversing switch changes rotation . . . many other features.
- Ideal for use on conveyors, pumps, mixers, shaker screens, packaging machines, fans and blowers, farm machinery, governor controls, similar machines.

For complete engineering data write for Bulletin SP-600

BALDOR ELECTRIC COMPANY
4353 DUNCAN AVE. ST. LOUIS 10, MISSOURI

Circle 509 on page 19

Which Packing



1. A run of 2,800 cycles, ended by excessive leakage, did this to a well-known make fabricated rubber packing. The test was run on a Justice testing machine at 4000 psi with a 6" stroke. Note that wear is at the heel, and that fabric is exposed and worn away.

Here's an example of Houghton's outstanding know-how

Which packing would you choose? At right you see the proof of the clear superiority of Houghton's new fabricated synthetic rubber cup packing No. 3081. After 22,000 cycles, it shows far less wear than a competitive fabricated rubber packing at 2,800 cycles. Actually, some makes lasted only 1000 cycles in this test.

Why do Houghton packings wear so much longer? First, the rubber itself has superior wear-resistance. It is a special Houghton high-density synthetic rubber. Fabric layers in Houghton packings are completely and uniformly covered with rubber. The rubber takes the wear. The fabric does *only* the reinforcing job it is supposed to do.

Because Houghton packings are pre-shaped, they don't distort under pressure. They don't have to "wear in" because they already have a pre-formed shoulder with minimum radius.

In addition, there's a PLUS feature. Instead of being surface-treated with graphite powder that wears off quickly after installation, Houghton packings are treated with a silicone lubricant to assure easy installation. It will not form valve-jamming sludge or residue in the hydraulic fluid, as graphite can.

Houghton's new #3081 packing is the hottest new development in packing science in years. Write today for Houghton's new fabricated packing bulletin—or ask the Houghton Man, the next time he calls. E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

Ran Longer?

2. After *22,000* cycles under the same conditions, Houghton's new fabricated No. 3081 cup packing still looked like this when leakage became sufficient to stop the test. The fabric is still completely and uniformly covered with rubber, even after 19,000 cycles more wear than the other packing could deliver.

in packing science... proved in a grueling comparison test

Houghton Offers a Full Line of Hydraulic and Pneumatic Packings in a Complete Range of Outstanding Materials

"V" PACKINGS	VIM Leather • Wax impregnated • Rubber impregnated • VIX-SYN Homogeneous synthetic rubber • Fabricated synthetic rubber
"U" CUPS	VIM Leather • Wax impregnated • Rubber impregnated • VIX-SYN Homogeneous synthetic rubber
CUPS	VIM Leather • Wax impregnated • Rubber impregnated • VIX-SYN Fabricated synthetic rubber
"O" RINGS	VIX-SYN synthetic rubber

GASKETS, SEALS AND MOLDED PARTS—Rubber or Leather

FLUIDS AND OILS

HOUGHTO-SAFE water-base and phosphate ester fire-resistant fluids • HYDROLUBRIC F. R. water-in-oil emulsion type fluid, for less hazardous applications • HYDRO-DRIVE hydraulic oil • HYDROLUBRIC additive for water hydraulic systems

products of...

E. F. HOUGHTON & CO.

PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO

Ready to give you on-the-job service...

Circle 510 on page 19

PROPORTIONEERS, INC.
look beyond the PRICE TAG
when selecting
WINSMITH SPEED REDUCERS

● Wherever fluid proportioning is used in industry, the Model 1106 Proportioneer Pump is known for its work-horse stamina, its watch-like accuracy. Helping to build this reputation for ruggedness and precision, Winsmith Speed Reducers have been selected for use on these pumps since 1932.

Proportioneers, Inc., a division of B-I-F Industries, rate performance as the main reason for continued selection of Winsmith reducers but in looking beyond the price tag and the performance they pay for — they find a highly important *extra* that's not for sale but given freely at Winsmith — that's *co-operation* in helping customers to solve speed reducer problems.

As Proportioneers, Inc., puts it: *"...co-operation is one of those things that can't be covered by a price tag but it is one of the big reasons why we have stayed so long with Winsmith."*

When you select Speed reducers, keep this *extra* in mind. The services of our engineering department are always at your service to help you select the right reducer for every application from 1/100 to 85 h.p.

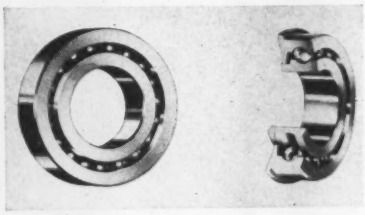
WINSMITH SPEED REDUCERS

WINSMITH, INC.
16 Elton Street
Springville (Erie County) N. Y.

Circle 511 on page 19

New Parts

(Continued from Page 189)



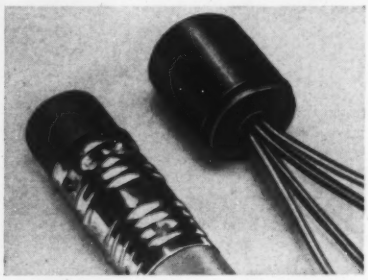
play. Integral labyrinth seals on one or both sides are available where sealed-type bearings are required. **Heim Co.**, 20 Sanford St., Fairfield, Conn.

Circle 708 on page 19

Miniature Transformers

for transistor circuits

Seven miniature DO-T transistor transformers weigh only 1/10-oz each and are fully sealed to MIL-T-27A specifications. Included in the group are 500 mw units designed for pushpull transistor to 600 ohm line, a chopper input transformer, transistor interstage



transformer, and a line-to-line matching transformer. **United Transformer Corp.**, 150 Varick St., New York 13, N.Y.

Circle 709 on page 19

Indicating Light

provides for built-in testing

PresTest oiltight indicating light offers a means of checking for faulty bulbs, without tools or dismantling, by pressing on the lens. Single-pole, double-throw momentary-contact switch is built into the unit. Normally closed position is on standard circuit; normally open position is on separate, constantly energized momentary-contact circuit. Full range of colors is available in both resistor and trans-

Circle 512 on page 19→

DOW CORNING CORPORATION

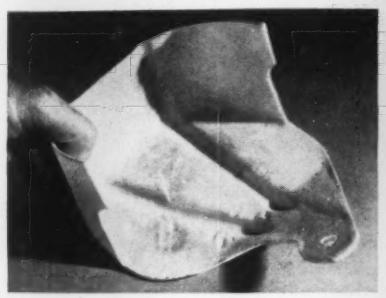
Silicone News

FOR DESIGN ENGINEERS No. 40

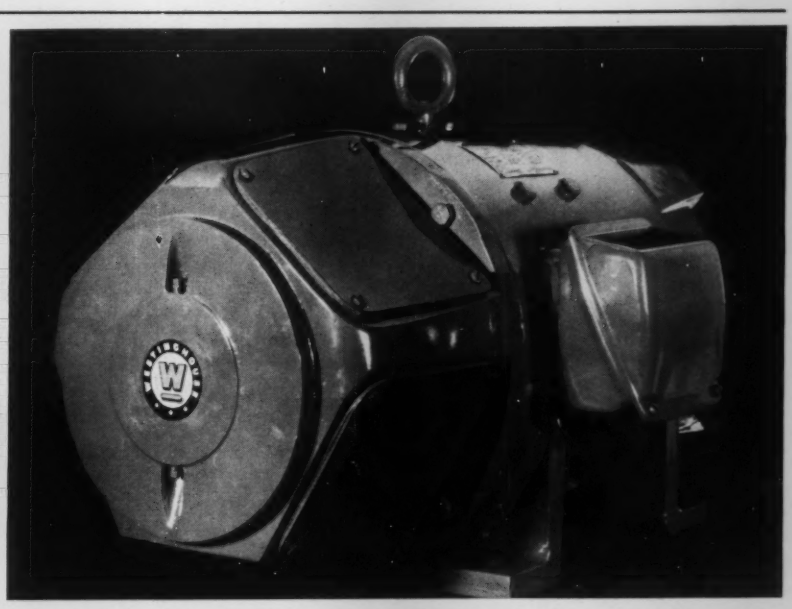
Silicone-Glass Heat Dam Combines Thermal Insulation, High Strength

Designers looking for a strong, lightweight, vibration-resistant material that will also serve as a thermal insulator or "heat dam" are finding the answer in silicone bonded glass laminates. A typical application is the generator wiring cap used successfully on one of the more popular jet engines.

The stamped metal covers previously used were notorious conductors of heat and none could long withstand the high-frequency, low-amplitude vibration



characteristic of jet engines. Maintenance and replacement costs were abnormally high until the engine manufacturer replaced the metal covers with caps made from silicone-glass laminate. (Cont. Pg. 2)



WESTINGHOUSE INTRODUCES STANDARD LINE OF SILICONE INSULATED D-C MOTORS

While most leading manufacturers of electrical equipment build silicone insulated units for special purposes, now for the first time Westinghouse's new Life Line "H" series offers the advantages of silicone insulation in standard "off the shelf" d-c motors and generators.

Dow Corning Silicones have been used in combining a high temperature insulating system with complements of copper and iron equal to those used in conventional Class B machines. As a result, these new motors and generators rated at Class B temperatures have at least 10 times longer insulation life.

In addition, Dow Corning silicones help provide extra protection against emergency overloads and abnormal ambients to reduce motor maintenance. Insulation is no longer a limiting factor to motor life. Already in production, the new dc motors span ratings from 1 to 150 hp: the dc generators are rated from ¾ to 100 kilowatts.

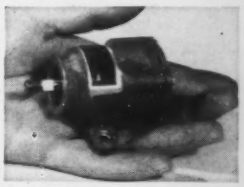
Life Line "H" equipment is designed to be especially useful for automated processing where insulation failure in one unit may shut down an entire assembly line throw-

(Cont. Pg. 2)

Silicone Fluids Provide More Uniform Vibration Damping

For reliable and uniform vibration damping, there's no more practical viscous medium than Dow Corning 200 silicone fluids. With their inherent thermal stability, these semi-inorganic fluids maintain near constant viscosity over exceptionally wide ranges of temperature. Here's how the Sesco Engineering Division of the Haines Gauge Company utilized the advantages of a Dow Corning 200 Fluid to engineer a smaller and lighter-weight vibration damper for use in aircraft.

This miniature damper gives accurate, reliable service at temperatures ranging from —60 to over 160 F. Because the use of Dow Corning 200 Fluid as the damping medium eliminates the need for a mechanical compensating device, the compactly designed unit weighs only 9 ounces filled.



It effectively smooths out unwanted vibration or "hunting"... and can be regulated to allow any desired amount of vibration in a system that is required to oscillate.

Ball-bearing equipped for minimum friction and sealed against atmospheric effects, the Sesco unit operates efficiently in any position. Special models for extremely low temperature use are equipped with seals and diaphragms made from Silastic*, the Dow Corning silicone rubber. *No. 406*

*T.M. REG. U.S. PAT. OFF.

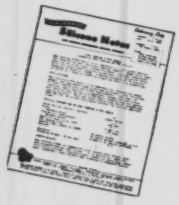
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Solventless Silicone Impregnating Resins now commercially available for electrical and electronic equipment, are free-flowing, can be blended, and have good pot life. On curing, these silicone encapsulating resins set to a solid mass having good electrical and physical properties; and retain such properties that a service life of 10 years at 400 F is indicated. *No. 410*

Silicone Insulated Motors Last Longer—Cost Less A new brochure bears out this fact with numerous case histories of motors operated for years under adverse conditions in many different industries. An illustrated booklet, it's sure to suggest ways in which you can use silicone insulation to obtain low-cost protection against the effects of overloads, high ambient temperatures, rapid reversing, moisture, and corrosion. *No. 411*

"Rubber From Rock," a new color-sound movie, explains how Silastic, the Dow Corning silicone rubber, is manufactured from quartzite. Demonstrates why parts fabricated from Silastic retain rubber-like properties from —130 to over 500 F in a wide variety of military and industrial applications. Also covers uses for Silastic as a dielectric in electronic and electrical equipment. To arrange for a showing of "Rubber From Rock" in your plant, circle ..... *No. 412*

Silastic 916, the first silicone rubber available that combines high strength with thermal stability, is serviceable from —130 to 500 F, has good electrical properties, and is easy to compound and process. *No. 413*

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists their applications, and cites factors which contribute to obtaining longer life. *No. 414*

Parts and components made with Dow Corning Silicone Molding Compounds are lightweight, show excellent resistance to heat, and have good structural and electrical properties. Used as brush holders, collector rings, terminal boards, multiple lead connectors, heat dams for turbine driven alternator bearings, and aircraft brake shoe backing. *No. 415*

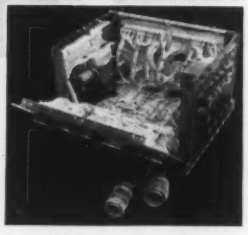
RELIABILITY OF "SNARK" MISSILE INSTRUMENTS ASSURED BY SILICONE RUBBER ENCAPSULATION

Engineers at Northrop Aviation take no chances on the performance of intricate high impedance circuits in the "Snark" guided missile, the F-89 Interceptor and other Northrop projects. They virtually "seal in" top performance by completely encapsulating the brains of these units in Silastic* RTV.

A new, easy-to-apply silicone dielectric that vulcanizes into a rubbery solid at room temperatures, Silastic RTV provides positive protection for even the most delicate electronic components. All panels containing resistors, capacitors, transistors and other recording and transmitting gear are embedded in this Dow Corning silicone rubber. According to Northrop engineers, a single coating—

- provides an effective cushion against vibration
- assures maximum moisture resistance
- improves electrical properties, especially surface resistivity
- protects assemblies against rough handling
- may be applied with a caulking gun

Another important advantage of using Silastic RTV in this application is the ease of inspecting or replacing individual components after assembly.



The silicone rubber "skin" is simply slit open to expose the component. Such openings are easily patched with more Silastic RTV.

Silastic RTV ranges from a heavy putty to a fluid-like consistency. It attains optimum physical and dielectric properties in 4 to 7 days. *No. 407*

*T.M. REG. U.S. PAT. OFF.

WESTINGHOUSE MOTORS *(continued)*

ing production schedules and costs way out of line.

The extra overload capacity provided by the silicone insulation system makes these motors ideal for conveyor, pump, blower and processing motors in mines; for drive motors in the glass, machine tool, paper and metals industries; for conveyor drive motors in material handling and many other processing industries.

The use of silicones in this complete line of standard motors within NEMA ratings is a big step forward in the accelerating trend toward more extensive use of silicone insulation systems. *No. 408*

"HEAT DAM" *(continued)*

Not only do the new silicone-glass caps afford better protection for the wiring at unusually high ambients, but the laminate actually has a higher strength-to-weight ratio than many light metals at elevated temperatures.

Bonded with Dow Corning silicone resins, the laminated glass caps are fabricated by Joclin Manufacturing Company, North Haven, Conn. They are supplied in various thicknesses ranging from 7 to 14 plys and maintain their complex, multiplane configuration perfectly despite exposure to severe vibration at operating temperatures as high as 500 F. *No. 409*

Dow Corning Corporation, Dept. 6819, Midland, Michigan

Please send me: 406 407 408 409 410 411 412 413 414 415

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

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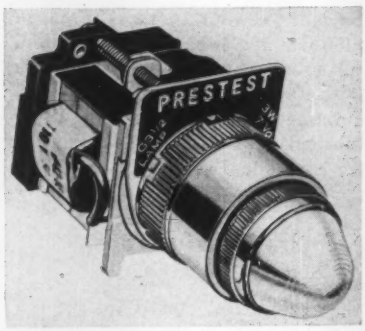
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS



former types. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee, Wis.

Circle 710 on page 19

Cap Nuts

of black Nylon

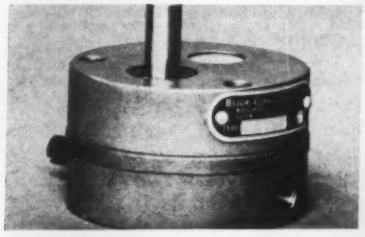
Knurled and slotted cap nuts of black Nylon can be used with rods or screws and also serve as knobs. They are useful in electrical installations where high dielectric strength and resistance to corrosion are important. Sizes, with American Standard threads, include 6-32, 8-32, 10-32 and ¼-20. **Weckesser Co.**, Dept. MDC, 5701 Northwest Highway, Chicago 30, Ill.

Circle 711 on page 19

Gear Pump

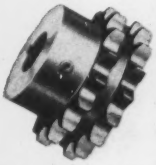
has 2½ in. diam and 1½ in. height

Unidirectional sealed gear pump can be mounted on any machine requiring fluid circulation for lubrication or other purposes. Designed to be driven from a rotating machine shaft, either directly or through gear or chain drive, pump is applicable to machine



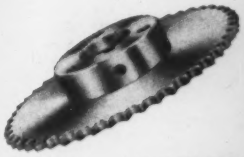
tools or other machines requiring flood lubrication over gear trains, chains or cams. Lip-style seal, located on drive shaft, withstands back pressures to 20 psi. Built-in relief valve prevents loading seal

STOCK BORE SPROCKETS

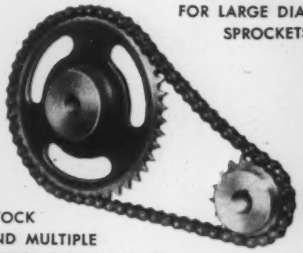


STEEL AND CAST IRON SINGLE SPROCKETS

CAST IRON HUB SPROCKETS



ALL STEEL SPLIT OR SOLID HUBS FOR LARGE DIAMETER SPROCKETS



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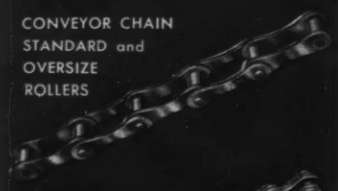

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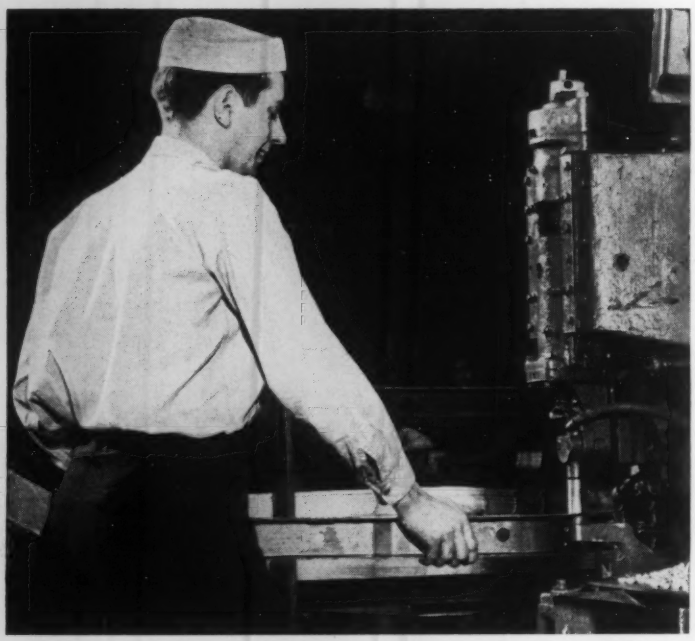
HOLYOKE MASSACHUSETTS

Circle 513 on page 19

MIDLAND

WELDING NUTS



take seconds to apply... save hours of labor!

If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

Write or phone for complete information!

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan

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AUTOMOBILE and TRUCK FRAMES • AIR and VACUUM POWER BRAKES

AIR and ELECTRO-PNEUMATIC DOOR CONTROLS

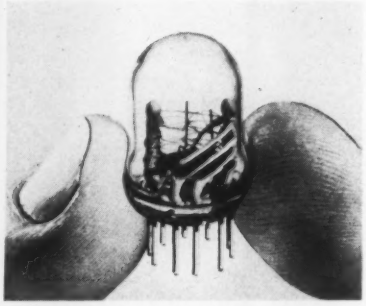
above rated limitations. Discharge is 50 cc per minute at 100 rpm, and recommended speed range is 20 to 1000 rpm. Pump is 2½ in. in diameter and 1½ in. high. **Bijur Lubricating Corp.,** 151 W. Passaic St., Rochelle Park, N.J.

Circle 712 on page 19

Miniature Read-Out Tube

is unaffected by environmental conditions

Miniature Nixie is a gas-filled, cold-cathode, ten-digit numerical indicator tube having a common anode. It is intended for use as a direct, in-line, read-out device. Unit is 6/10-in. in diam and ¾-in.



high. It utilizes 100 v and operates at ⅛ w. Tube is unaffected by environmental conditions. Applications include aircraft instrument panels, computers, industrial control, counters, military electronic indicators, digital voltmeters, fluid meters, elevators and channel indicators. **Burroughs Corp.,** Electronic Tube Div., Plainfield, N.J.

Circle 713 on page 19

Large Induction Motors

designed for lighter weight, smaller size

Redesigned ac induction motors from 40 to 125 hp include both open drip-proof and totally-enclosed, fan-cooled units. Built to NEMA standards MG1-3.02.a, MG1-5.05.b and MG1-5.02.d, the models are from 100 to 500 lb lighter than their predecessors. Lineal dimensions have been reduced an average of 10 per cent and volume an average of 27 per cent. Savings have been achieved largely through insulation im-

Circle 514 on page 19

ENGINEERS... DESIGNERS... P.A.'S

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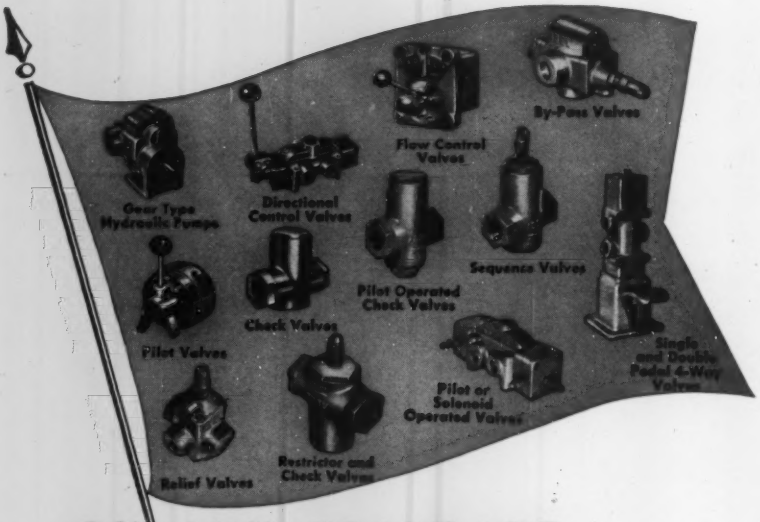
Circle 515 on page 19



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ADEL *Refinements* assure Plus Performance for Your Equipment

Designers and Engineers have set these standards for Industrial Hydraulic Equipment

Rugged simplicity • Long life • Simplification of piping • Reduced installation costs • Greater accessibility for maintenance • Completeness of line • Over-all economy

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Illustrated are but a few of a wide variety of ADEL industrial hydraulic control equipment that offer definite benefits to both the user and builder of machine tools and many other kinds of equipment. ADEL products incorporate proven design and precision construction features that assure dependable operating efficiency over the years. A complete line for every application. You can simplify your Hydraulic Power Motion Problems by specifying ADEL.

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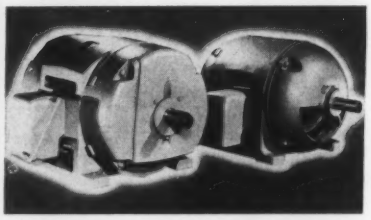
Circle 516 on page 19

New Parts



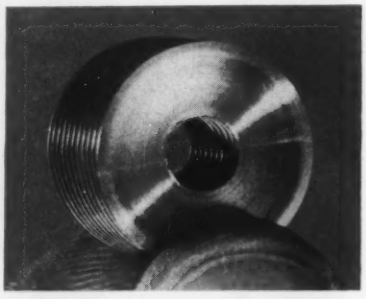
provements which permit use of thinner materials. Improved lubrication system protects bearing housing from dirt and allows necessary regreasing. Shown in photo is new motor, left, rated 125 hp, and old motor, rated 75 hp. **General Electric Co.**, 1 River Rd., Schenectady 5, N.Y.

Circle 714 on page 19

Bellows

for miniature devices

Extremely flexible bellows have wall sections as thin as 0.002-in. Available in any weldable metal, the bellows permit miniaturization



of devices for measuring pressure, and as a seal. Unit illustrated is approximately ¾-in. OD by ¼-in. ID by ½-in. long, and has spring rate less than 7 lb per in. **Belfab Corp.**, 11 Ramah Circle, Agawam, Mass.

Circle 715 on page 19

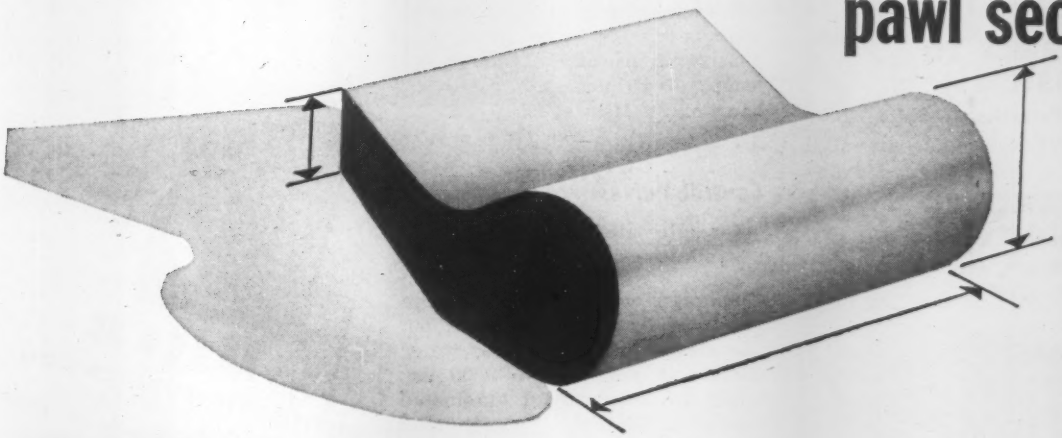
Unitized Assembly Circuit

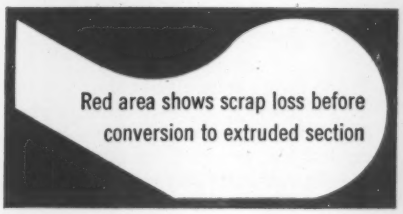
has simplified chassis design

PAC unitized assembly circuit, for use in conjunction with printed wiring applications, permits the insertion as a group of a wide range of capacitors, resistors in simple or complex circuitry. Components available include a range of capacitances in tubular ceramic capacitors and resistances in fixed-com-

52% saving

reported with J&L hot extruded cold drawn pawl section





This pawl was previously milled from a ¾" x 1½" hot rolled oil hardening tool steel. Conversion to a cold drawn extruded section cut cost from 45¢ to 22¢ per part.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 410, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin
STEEL ... a great name in steel

Circle 517 on page 19

Do you need
PRECISION
anti-friction
BEARINGS

for
HIGH-TEMPERATURE SERVICE to 500° F — 1000° F — 1500° F ?

for
RESISTANCE TO CORROSION by Acids — Caustics — Salts ?

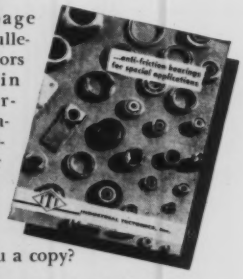
for
RESISTANCE TO ABRASION by wet or dry grit, silt, etc. ?

with
NON-MAGNETIC PROPERTIES, electrical conductance, etc. ?

with
SPECIAL SHAPES AND SIZES, low torque, ultra precision . . ?

WE MAKE bearings to these and other special requirements, in experimental and production quantities. We've been doing that for years, for well-known firms. So if *you* need special anti-friction bearings for *any* application, let's talk it over.

FREE 32-page Bearings Bulletin tells factors involved in special bearing applications — describes our work in this field.



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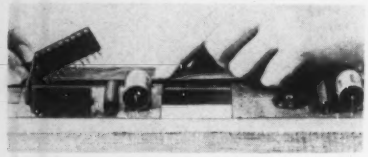
ITI
PRECISION BALLS AND SPECIAL ANTI-FRICTION BEARINGS

Circle 518 on page 19

New Parts

position resistors. Packaged circuit has simplified chassis design and assembly, and provides rugged construction, high component density due to vertical mounting, and low uniform stray capacitance. Center-



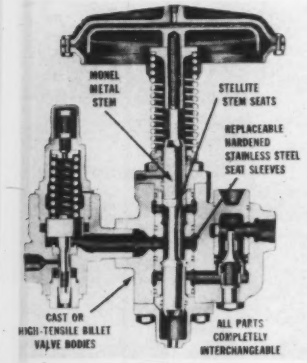
to-center spacing between components is 0.200-in. Number of components in package is limited by length of strip used. **Speer Carbon Co.**, St. Mary's, Pa.

Circle 716 on page 19

Control Valves

for automated control applications

Diaphragm-operated high-pressure control valves are for use in oil, air, steam and hot or cold water service at pressures to 6000 psi. Units are designed for automated control applications. Monel-metal valve stem provides resistance to corrosion. Stellite seats are elec-


MONEL METAL STEM
STELLITE STEM SEATS
REPLACEABLE HARDENED STAINLESS STEEL SEAT SLEEVES
CAST OR HIGH-TENSILE BILLET VALVE BODIES
ALL PARTS COMPLETELY INTERCHANGEABLE

trobonded to the stem, and stainless-steel seat sleeves are easily replaceable. **Sinclair-Collins Valve Co.**, 454 Morgan Ave., Akron 11, O.

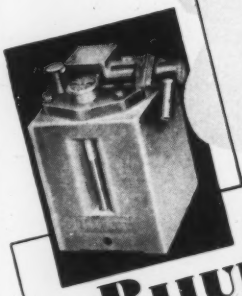
Circle 717 on page 19

Miniature Relay

for high shock and vibration applications

MHJ miniature relay has a vibration rating of 10-55 cps at 0.125-in. double-amplitude, 55-2000 cps at 20 *g*. It is available in both four

YOUR SILENT PARTNER



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HELPS YOU
• effect real savings in your own plant
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Hand oiling is costly! It wastes time and money . . . steals valuable production hours . . . means extra down-time, fire risk, repair bills, replacement parts and causes product damage from excess lubricant.

But there's a way to end all this waste and worry. A Bijur Automatic Lubrication System never forgets a bearing . . . bearings never are thirsty for oil, never flooded. Lubrication is continuous, exactly right. All the hazards of hand oiling are banished—*automatically!*

Bijur Systems are custom-engineered for machinery used by practically all industries. Every bearing receives a clean supply of oil at the right time . . . automatically and correctly metered to suit its individual needs . . . while the machine is running! Whether for new equipment you *buy*, or machines you *build*, insist on Bijur. It's better—*by design!*

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Circle 519 on page 19

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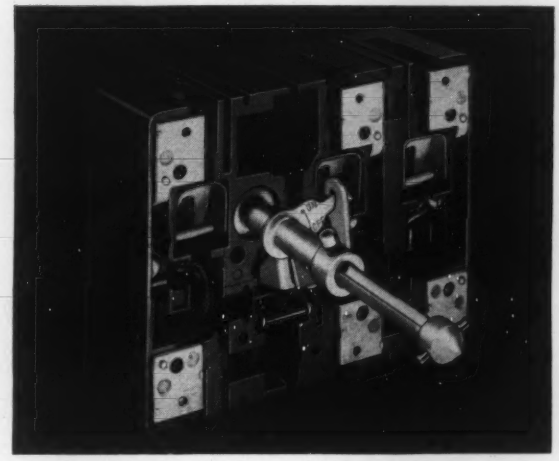

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NEW

Westinghouse VISI-FLEX De-ion Switch fits any panel

• ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE •

This compact new type of panel switch features . . .

- Visible contacts
- Fused or unfused operation
- Choice of Vari-depth or toggle handle
- Standard cover drilling
- Fast mounting
- Low cost

Quick-make, quick-break action plus De-ion arc-quenching grids assures positive switching, long operating life. Ready visibility of the blades means extra safety.

The Vari-depth operator, featuring a threaded telescoping shaft, makes it easy to fit panels of various depths . . . without mounting stilts. It also simplifies cover drilling.

Fuse kits permit mounting several sizes of fuse clips on the switch. As a fused switch, Visi-Flex saves space and the cost of separate fuse blocks.

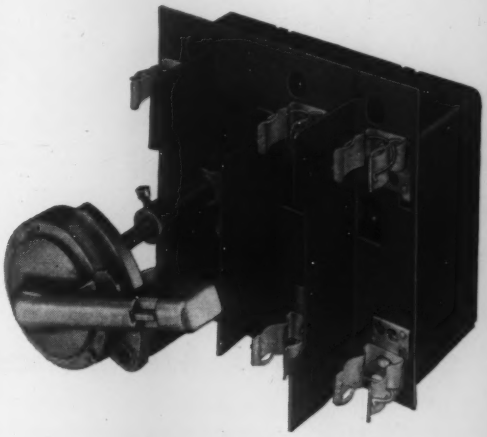
For use as a disconnect switch, a safety shield without fuse clips is available. You just order the basic switch and the required kit . . . all hardware is included.

Low in cost, flexible, simple to install, Visi-Flex requires a mininum of space. Visi-Flex switches come in 30- and 60-ampere ratings. 100- to 200-ampere models available later.

For additional information write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa., for Booklet SM-5457.

J-30276

Model A has adjustable Vari-depth handle mechanism—shown with fuse kit assembled. Also available with safety shield for no-fuze operation.



Model T has toggle handle for slide plate or cam-type mechanism—shown with a safety shield for no-fuze operation. Also available with several sizes of fuse clips.

YOU CAN BE SURE...IF IT'S Westinghouse

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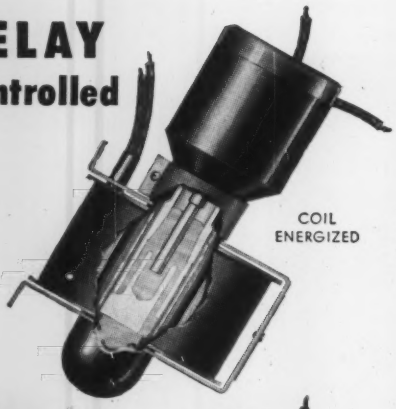
The **TIMER RELAY**
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool
STEEL MERCURY TIMERS

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer

See telephone directory for local distributor, or write.

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Circle 521 on page 19

RMB *Pivot Type*
Miniature Ball Bearings
Self-Aligning Feature
Means Faster Assemblies

Type C1
World's Smallest Commercial Ball Bearing—.043" OD

These RMB bearings were the first miniature bearings ever produced. Included in this group and illustrated above is the smallest ball bearing ever manufactured commercially—Type C1- .043" OD.

RMB Pivot Bearings can be used to replace jewel bearings where excessive shock and vibration conditions exist.

Inexpensive RMB pivot type miniature ball bearings are also used in aircraft instruments; for mounting the compensating rotor in constant speed DC motors; for the mounting of indicating pointers in instruments; relays, and a host of others.

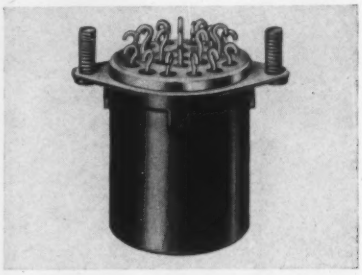
Designed for use with 60° tapered pivots, they are self-aligning for faster assemblies; and combine precision workmanship, high speed and low torque with low cost.

Pivot type miniature ball bearings are just a small part of the complete world famous RMB line of miniature and instrument bearings, available for prompt delivery. For full information, write for our catalog 41.

LANDIS & GYR, INC.
45 West 45th Street • New York 36, N. Y.

Circle 522 on page 19

New Parts



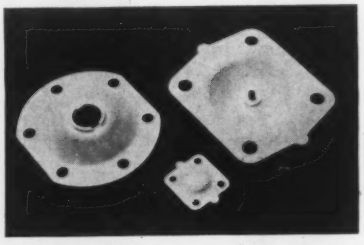
and six-pole, double-throw types. Temperature range is −65 to 125 C. Relay meets test conditions of MIL-R-5757B, MIL-R-6106A and MIL-R-25018. **Allied Control Co. Inc.**, 2 East End Ave., New York, N.Y.

Circle 718 on page 19

Diaphragm Shields

of Teflon and Kel-F

Seven sizes of standard molded Teflon and Kel-F diaphragm shields fit diaphragm valves in sizes 3 in. Shields, installed over a rubber diaphragm provide corrosion and heat resistance and resist all chemicals normally found in industry. They are attacked by molten alkali metals, chlorine trifluoride, and fluorine at elevated temperatures and pressures. Shields are unaffected by alkalis in any concentration, and will not swell or



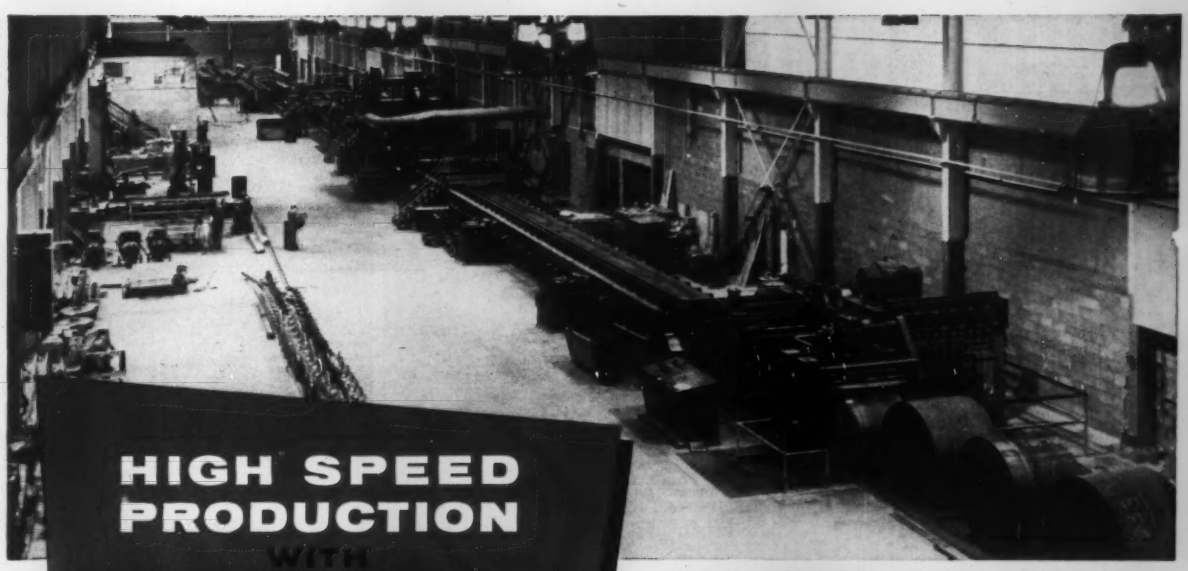
change weight when boiled in solvents or acids. Temperatures of 350 F and higher are possible where low line pressures exist. **Garlock Packing Co.**, U. S. Gasket Co. Div., Camden 1, N.J.

Circle 719 on page 19

Connectors

for printed circuits

Printed - circuit connectors are available in eight different sizes from 6 to 38. Coined beryllium copper contacts are 0.058-in. wide,



HIGH SPEED PRODUCTION WITH RELIANCE V★S DRIVES

Six Reliance V★S Drives make it possible to operate this complete line as if it were a single machine.

Carloads of pipe are pouring out of the new Edmonton, Alberta plant of Alberta Phoenix Tube & Pipe, Ltd. This $6.5 million installation is producing pipe at unprecedented rates.

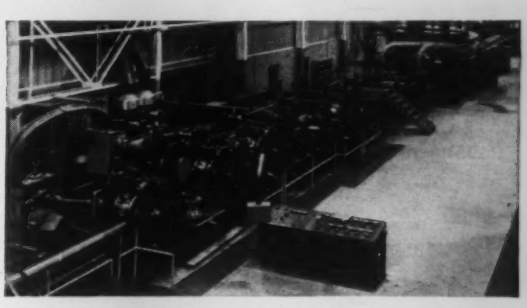
Volume pipe production requires something special in a drive system—one that furnishes precise speed control and instantaneous motor response. A wide stepless range of speeds is provided to handle various pipe diameters and lengths, and all sections of the line operate at the same relative speed.

A team of Reliance Application Engineers, working with the machinery builder, built this specialized drive. This team knows the processes of the steel industry and how to handle the problems involved. Engineering knowledge, backed by the quality of Reliance products, supplied this accurate, simple-to-operate, economical drive.

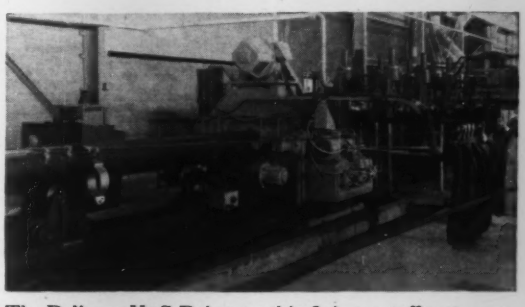
The Reliance Application Engineering Department builds drives for every industry. A team of engineers who are experts on your industry's operation, stand ready to engineer and build the drive for your particular needs.

If you would like more information on this installation, write for Bulletin L-2505.

L-1541



The welding section operator controls the speed of the entire line from this Reliance Pendent Station.

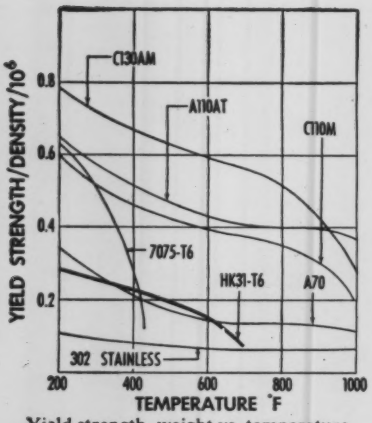


The Reliance V★S Drive on this flying cutoff automatically measures the pipe and controls the movement and speed of the carriage.

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 287A, CLEVELAND 17, OHIO • CANDIAN DIVISION: WELLAND, ONTARIO

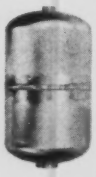
Sales Offices and Distributors in Principal Cities

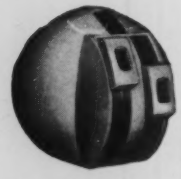


Yield strength, weight vs. temperature.

For High Strength-to-Weight Ratios at Elevated Temperatures— TITANIUM and MAGNESIUM

The experience, the specialists, the equipment-and-facilities to design and produce the *very difficult* fabrication and assembly work in these and other light metals—you'll find at B&P.


To make this titanium pressurized tank, B&P welds two cylinders. Each is drawn in one operation. Tank withstands 5000 psi pressure.


Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.

ENGINEERING FACILITIES IN DETROIT AND LOS ANGELES . . Write for Titanium and Magnesium engineering data—also folder on B&P's facilities to handle tough jobs.

BROOKS & PERKINS, Inc.

1940 West Fort St.
Detroit 16, Mich.
Phone: TAshmoo 5-9900

IN LOS ANGELES:
11651 VanOwen St
North Hollywood, Cal.
Phone: STanley 7-9665

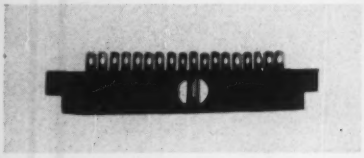
56 A

OFFICES IN NEW YORK, WASHINGTON, DALLAS

Circle 524 on page 19

New Parts

and are heat treated to retain contact force after many insertions. Ample contact mass insures lower heat rise at rated loads. Barriers between terminals insure high voltage breakdown ratings exceeding 2500 v rms at sea level and 700 v rms at 60,000 ft. Models are avail-



able for printed-circuit board thicknesses from 0.061 to 0.071-in. Polarizing pins can be located in any slot desired. Units meet requirements of MIL-C-8384. **Gorn Electric Co. Inc.,** Electronics Div., 845 Main St., Stamford, Conn.

Circle 720 on page 19

Magnetic Clutch

is miniature, single-end unit

Model D104 miniature single-end magnetic clutch brake mets military environmental and performance specifications. Standard model operates on 24 v dc can be wound for 1.5 to 300 v. It delivers minimum of 8 oz-in. clutching and braking torque. Response time is as low as 3 milliseconds and angu-

lar displacement error upon engagement is held to minimum. Power consumption is 3 w. Mounting has OD of 1 1/16 in. **Dynamic Instrument Corp.,** 59 New York Ave., Westbury, L. I., N.Y.

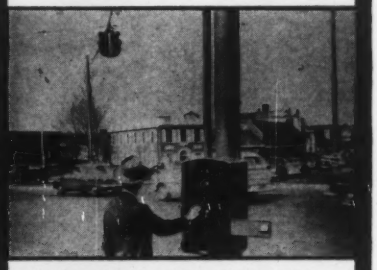
Circle 721 on page 19

Indicator Tube

is miniature type for transistor circuits

Type 6977 filamentary indicator triode with fluorescent anode is a subminiature unit designed specifically for visual monitoring of

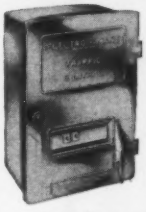
TCB = ? TCB = HB



Problem: What method can best be employed to cast our large Traffic Control Box . . . and who can satisfy our exacting requirements?

Solution: Aluminum Permanent Mold Casting . . . by Hampden Brass & Aluminum Co.

This was the solution Eastern Industries, Inc. found to their problem of housing the delicate "brain" of their radar traffic control system.


Pictured here is the end result . . . a non-corrosive, uniquely weather-proof, snug-fitting box, completely safe from tampering.

The permanent mold process was chosen by Hampden because it produces a fine, non-porous casting . . . the surface requiring no preparatory finishing before painting. The box was used as cast, thereby eliminating expensive profile machining for producing the rabbet fit of the box and doors. The high production rate and lower over-all cost of the permanent mold process prove additional advantages. Aluminum was selected for its lightweight and durable qualities.

Remember . . . whether your casting problems are big, tiny, intricate, or special . . . Hampden is ready to effectively solve them with premium quality castings of aluminum or other non-ferrous metals . . . utilizing the sand, permanent mold or die casting method. Our more than 50 years' know-how is your assurance of the best casting techniques to help reduce costs and improve performance.

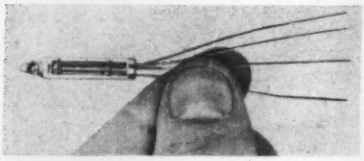
Why not contact Hampden Brass & Aluminum Co. on your next casting problem . . . and avail yourself of our engineering counsel?

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden's experience, equipment and facilities.

HB

HAMPDEN BRASS AND ALUMINUM CO.
Established 1903
262 Liberty St.•Springfield, Mass.
Producers of Sand, Permanent Mold, Die & Fiberglas Castings

Circle 525 on page 19

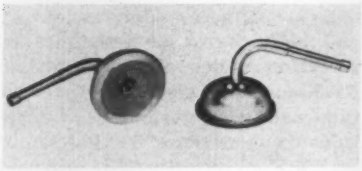


transistorized computers and other transistor circuits. Approximately 1⅛ in. long and less than ¼-in. diam, it gives a bright blue-green indication when control grid is at zero potential. Unit has high input impedance and small power consumption to prevent overloading of transistor circuits. It does not short out transistor circuit should a defect develop in operation. **Amperex Electronic Corp.,** Computer Products Div., 230 Duffy Ave., Hicksville, L. I., N.Y.

Circle 722 on page 19

Ball and Socket Joint

incorporates polyethylene molding



Ball and socket joint has a socket of polyethylene molded within a metal housing. Nickel-plated brass ball and arm assembly are housed in casing of turned aluminum. Joint remains flexible but will not loosen. It is permanent, and polyethylene molding provides all characteristics of a lubricated joint. Unit is manufactured on a custom basis in several different sizes and styles. **Telex,** Telex Park, St. Paul 1, Minn.

Circle 723 on page 19

Flow-Blending Control

provides continuous blending and proportioning

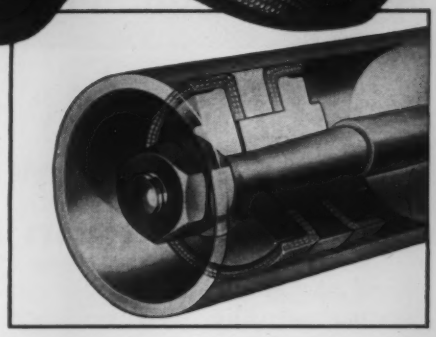
Blendtrol is used to maintain flow rates in closed loop systems or to blend and proportion in open-loop systems. It handles a variety of products, including oils, inhibitors, solvents, soaps and waxes. An electronic controller, unit can be located several thousand feet from the process. It is designed to be

PUMCUP ADVANTAGES

now yours for

- HYDRAULIC CONTROLS
- AIR CYLINDERS
- RECIPROCATING PUMPS

Two common Pumcup types: conventional and 45° bevel type . . . available in a complete range of sizes and texture-engineered compositions.



Cutaway view of typical Pumcup installation resulting in prolonged high efficiency.

TAKE it from experienced users, Darcova Pumcups offer payoff advantages that can't be equalled! For example, they last many times as long as ordinary piston packing . . and they *hold peak efficiency* from start to finish. Because of the resulting production and maintenance economies, plant after plant is standardizing on Pumcups.

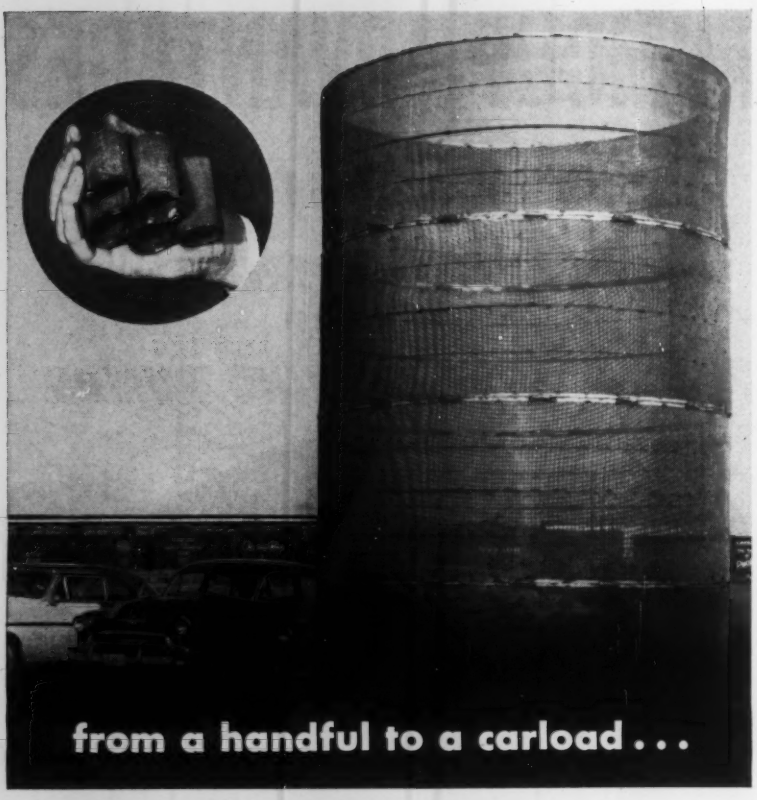
Improved application of the cup principle does the trick. And Darcova Pumcups are *texture-engineered* in *a range of compositions* to meet most temperature-pressure-fluid conditions. And they are available in sizes and types exactly right for your particular equipment.

It will pay you to get *all* the facts. Just ask for Pumcup Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.
Williamsport 30, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
TRADE MARK
PUMCUPS

Circle 526 on page 19



Cambridge offers you complete wire cloth fabrication facilities

From giant retaining screens for catalysts or filter media to small strainer assemblies for Diesel engines, fabrication of wire cloth parts to a wide variety of demands is a daily operation at Cambridge. Whatever your needs . . . filter leaves, strainers, sizing screens, retaining screens . . . you can rely on Cambridge for quality and prompt service. We'll work from your prints or draw up prints for your approval.

IF YOU BUY WIRE CLOTH IN BULK, we can give you immediate delivery from stock on large or small orders from the most frequently used types of cloths . . . from the finest to the coarsest mesh.

Accurate mesh count and uniform mesh size are assured by individual loom operation and careful inspection just before shipment.

Let us quote on your next order for wire cloth. Call your Cambridge Field Engineer—he's listed under "Wire Cloth" in your classified telephone book. Or, write direct for FREE 90-PAGE CATALOG and stock list giving full range of wire cloth available. Describes fabrication facilities and gives useful metallurgical data.

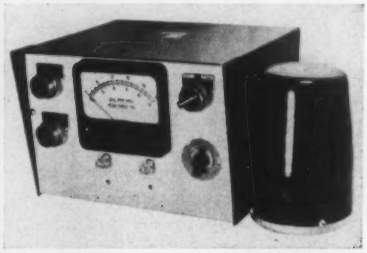
The Cambridge Wire Cloth Company

WIRE CLOTH | WOVEN WIRE CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

DEPARTMENT N,
CAMBRIDGE 7,
MARYLAND

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

New Parts



adapted to proportioning systems now in operation. Explosionproof enclosures are available. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 724 on page 19

Silicone Rubbers

for cloth-coating applications

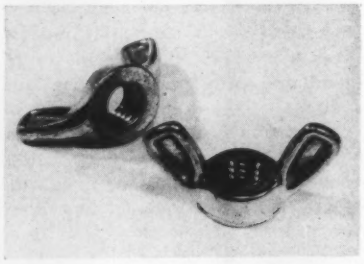
Two silicone rubbers are for use in temperatures in range of 600 F. Identified Silastic 6535 and 2071, both are primarily cloth-coating stocks characterized by excellent bond strength, low compression set, and high degree of resistance to reversion under clamps. Silastic 6535 is a liquid dispersion for solution-coating on glass cloth. It retains resilience from 600 F down to − 178 F. Silastic 2071, designed especially for calendering, is also suitable for molding or extruding. After 24 hr in a circulating air oven at 600 F, it has Shore A Scale hardness rating of 63, tensile strength of 770 psi and 200 per cent elongation. **Dow Corning Corp.**, Midland, Mich.

Circle 725 on page 19

Wing Nuts

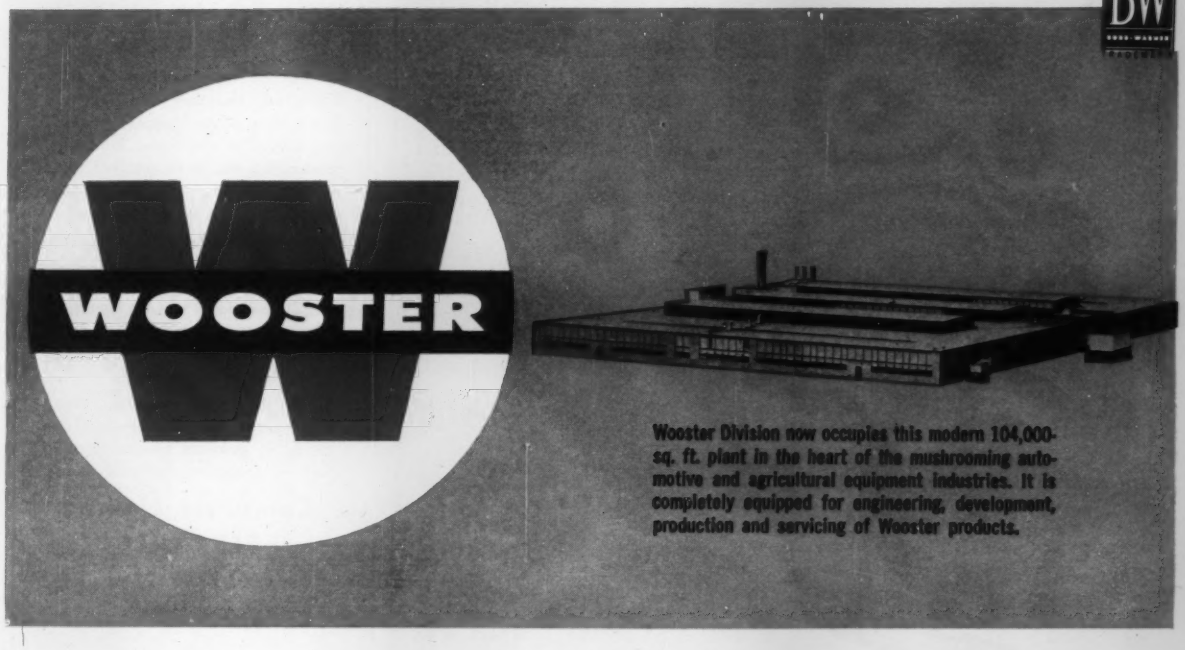
in thread sizes from No. 6 to ⅜-in.

Corrosion-resistant wing nuts are die-cast of zinc alloy and have wing spread from ¾ to 1⅛ in. Thread sizes are from No. 6 to ⅜-



NOW! industrial hydraulic equipment from

WOOSTER DIVISION


WOOSTER
Wooster Division now occupies this modern 104,000-sq. ft. plant in the heart of the mushrooming automotive and agricultural equipment industries. It is completely equipped for engineering, development, production and servicing of Wooster products.

Growth has led to the establishment of the Industrial Division of Pesco Products as a separate Borg-Warner facility—the Wooster Division.

This division will specialize in hydraulic pumps, motors, power packages and other accessories for *industry*—automotive, earthmoving, agricultural, material handling.

Here's how this will benefit users of industrial hydraulic equipment:

- **high product quality**—long associated with Pesco—will be assured from Wooster. Pesco "know how" plus a complete staff of experienced engineering, sales and production personnel has been installed at Wooster.
- **improved deliveries** from increased manufacturing facilities devoted exclusively to *industrial hydraulic equipment*.
- **better service** through close personal attention to customer requirements will be a Wooster operating policy.
- **advanced designs**—the result of extensive research facilities and development programs—will be a Wooster forte, in the Pesco tradition.

For detailed information or engineering assistance in applying Wooster hydraulic equipment to your products, contact the sales office nearest you or the main office.

WOOSTER PRODUCTS:

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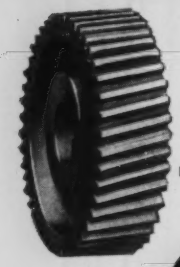
BORG-WARNER

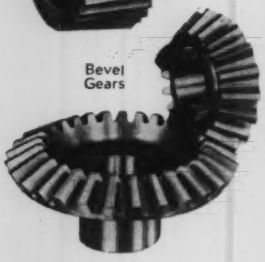
Circle 528 on page 19

GEARS

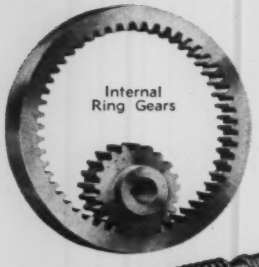
Symbol of QUALITY



Helical Gears



Bevel Gears



Internal Ring Gears

Worm Gear & Shaft

Industrial Gear offers a complete line of the finest cut gears available for the equipment of America. **Plus** — a combination of precision and quality, reasonable costs, and superb service.

INDUSTRIAL GEAR MFG. CO.
4515-39 West Van Buren St.
Chicago 24, Illinois

Circle 529 on page 19

New Parts

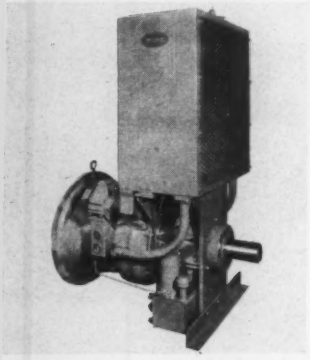
in. Nuts are also available with serrated bases to provide locking action when nut is seated. Recessed wings provide an improved grip. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N.Y.

Circle 726 on page 19

Torque Converter

has maximum rating of 586 hp at 2200 rpm

Heavy-duty 11,500 Series three-stage torque converter has maximum rating of 586 hp at 2200 rpm. Impellers are available for specific torque ratings of 340, 390, 450 and 540 lb-ft. Maximum input torque is 1400 lb-ft. Model CF provides



a clutch at the flywheel; Model F is connected to the flywheel with a driving ring. Both types are designed for SAE No. 0 flywheel housings. **Twin Disc Clutch Co.**, Hydraulic Div., Rockford, Ill.

Circle 727 on page 19

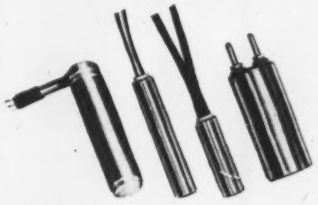
Binding Posts

in five-way, five-color types

Five-way binding posts accommodate connections by (1) plug-in for standard ¾-in. banana plug, (2) clip-lead to shaft, (3) wire looped around shaft and clamped, (4) wire permanently clamped through center hole, and (5) clamped spade-lug connection. A ⅛-in. flanged solder tip provides rigid base for permanent solder connection. Posts are available in white, red, yellow, green and black. They are hard Nylon, plastic molded over brass core. Center shaft is brass or nickel-plated metal finish, and posts can be

When to specify

VULCAN ELECTRIC CARTRIDGE HEATERS



1. When application is for: Complete insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc.

2. When specifications call for: Length—1" to 25" (or longer); diameter—¼" to 1 19/64" (or greater); wattage — 10 to 3200 (or higher); voltage — standard 115 or 230, special 6 to 440; sheath — brass, steel, nickel or high temperature alloys; standard or special lead wires or terminals.

3. When you have "hot" problems: Vulcan Engineers are ready to provide special heating units — engineered to your needs.

***Complete Line of* ELECTRIC HEATING UNITS**

Whatever your need for electric heat, Vulcan offers you a complete line of low-cost, efficient units — cartridge, strip, tubular, finned, immersion, band and ring heaters. Write for catalog.

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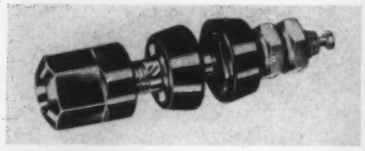
Circle 530 on page 19



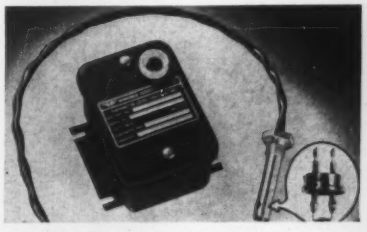
mounted and locked on any panel from 1/16 to ¼-in. thick with complete installation from panel. Current capacity is 30 amp; working voltage is 1000 v. **Superior Electric Co.**, Dept. BP, 83 Laurel St., Bristol, Conn.

Circle 728 on page 19

Liquid-Level Sensor

resists vibration, corrosion and shock

Liquid-level sensing system operates a light to indicate whether liquid is above or below a certain level, actuates a control to start and stop pumps, or operates valves to transfer liquid from one tank to another. It resists shock, vibration and corrosion, and has no moving parts. Ac or dc powered, it has low power consumption. System operates in any military aircraft fuel, hydraulic fluid, aircraft gas tur-



bine lubricating oil, Skydrol, jet engine lubricating oil, aircraft engine lubricating oil and other hydrocarbon liquids, from 75 to −55 C. **Simmonds Aerocessories Inc.**, 105 White Plains Rd., Tarrytown, N. Y.

Circle 729 on page 19

Diaphragm Seals

in miniature sizes

Miniature diaphragm seals are for small power devices and instruments in which size and weight are critical factors. They are available with cylinder-bore diameters from ½ to 1 in. Flange operates as a gasket, sealing mating surfaces in cylinders of two-piece design. Impregnated fabrics provide resistance to fatigue and chemical

CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener... in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

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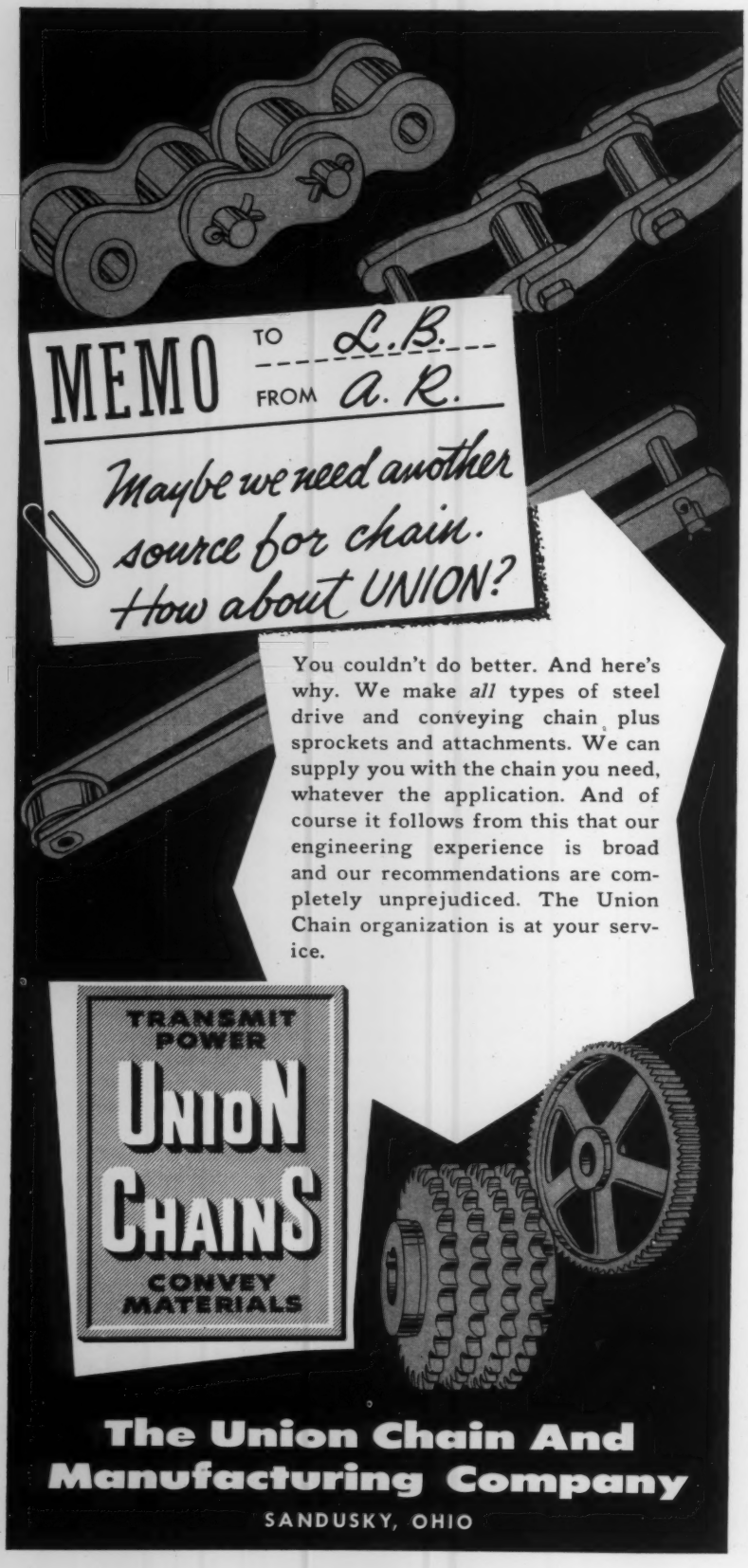
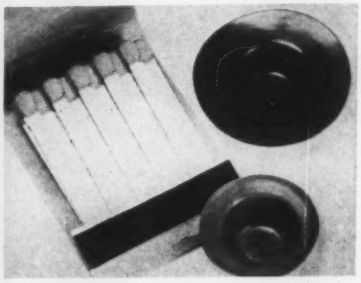
Circle 531 on page 19


MEMO TO L.B.
FROM A.R.
Maybe we need another source for chain. How about UNION?
You couldn't do better. And here's why. We make all types of steel drive and conveying chain, plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

New Parts



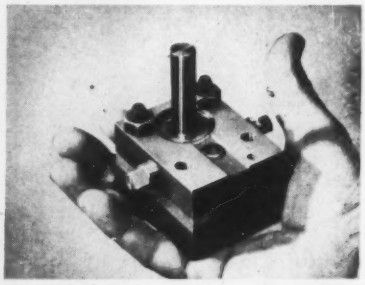
action. Operation is practically free of friction or spring gradient. Accurate and sensitive, the seals are free-positioning. **Bellofram Corp.**, Blanchard Rd., Burlington, Mass.

Circle 730 on page 19

Hydraulic Pump

has capacity of 0.5 gpm at 1000 psi

Detroit 1000 wet-sump hydraulic gear-type pump contains hardened steel and bronze gears, latter ball-bearing mounted at both ends. All wearing surfaces are hard-chrome plated. Initially produced for use within a fluid reservoir, units are available with sealed adaptations for mounting externally. Pump



has rated capacity of 0.5 gpm at 1000 psi and 1800 rpm. **Detroit Testing Machine Co.**, 9390 Grinnell Ave., Detroit 13, Mich.

Circle 731 on page 19

Magnetic Components

resist vibration and shock

Components and assemblies for applications such as magnetic amplifiers, modulators, voltage references and frequency multipliers are lightweight, compact and well protected environmentally. New techniques for encapsulating provide

Circle 532 on page 19

Circle 533 on page 19→

Sales and Service from Coast to Coast

. . . for quick, personalized service on your POWER CYLINDER NEEDS

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Denver—Alta Engineering Co., 1988 Nome St. Phone Empire 6-3557

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Hartford—Gibson Engineering Co., 141 Washington St. Phone Chapel 7-6919

GEORGIA

Atlanta—Miller Fluid Power Div., 254 East Paces Ferry Rd., N.E. Phone Cedar 7-9933

KANSAS

Kansas City, Mo.—Miller Fluid Power Div., 410 West 40th Terrace. Phone Valentine 1-7475

ILLINOIS

Chicago (Home Office) — Miller Fluid Power Div., 2040 N. Hawthorne Ave., Melrose Park, Ill. Phone Fillmore 3-4500

Rockford—Miller Fluid Power Div., 4712 Cayuga. Phone Rockford 7-1308

INDIANA

Fort Wayne—Neff Engineering Co., 2339 Crescent Ave. Phone Eastbrook 7391

South Bend—Neff Engineering Co., 103 S. Varsity Drive. Phone Central 2-4856.

Indianapolis—Neff Engineering Co., 6101 College Ave. Phone Clifford 5-5418-19

IOWA

Miller Fluid Power Div., 916 25th St., Moline, Ill. Phone Moline 2-4282

KENTUCKY

Louisville—Charles Weber Co., 536 Eastern Parkway. Phone Melrose 7-2574

MARYLAND

Baltimore—Miller Fluid Power Div., 1515 Kirkwood Rd. Phone Ridgeway 7-9424

MASSACHUSETTS

Boston—Gibson Engineering Co., 1018 Commonwealth Ave. Phone Aspinwal 7-5074

MICHIGAN

Detroit—Miller Fluid Power Div., 7338 Woodward Ave., Rm. 404. Phone Trinity 2-1441

Grand Rapids—J. N. Fauver Co., 2147 Englewood Drive. Phone Cherry 5-1247

Flint—J. N. Fauver Co., G. 3140 E. Hemphill Rd. Phone Pilgrim 2-3300

MINNESOTA

Minneapolis—Miller Fluid Power Div., 2800 Foshay Tower. Phone Federal 5-0449

MISSOURI

St. Louis—Sturgis Equipment Co., 601 S. Taylor Ave. Phone Olive 2-5380

NEW YORK

New York City—C. H. Ribble Co., 31 Di Carolis Court, Hackensack, N. J. Phone Diamond 2-2602

Rochester—Miller Fluid Power Div., 114 Thistledown Dr. Phone Congress 6-1660 or Browning 1-2109

Buffalo—Miller Fluid Power Div., 28 Church St. Phone Madison 3993

OHIO

Akron-Youngstown—Miller Fluid Power Div., P. O. Box 150, Sebring, Ohio. Phone Sebring 8-6368

Cleveland—Miller Fluid Power Div., 12703 Triskett Rd. Phone Clearwater 2-3131

Dayton—K. C. Mosier Co., 628 Ludlow. Phone Michigan 9805

Columbus—K. C. Mosier Co., 549 N. Columbia. Phone Capital 1-7120

Lima—K. C. Mosier Co., 1566 N. Union. Phone 6-8616

Cincinnati—K. C. Mosier Co., 6119 Cary. Phone Garfield 1-1023

Toledo—J. N. Fauver Co., R.F.D. Dutch Road, Waterville, Ohio. Phone Waterville 3598

PENNSYLVANIA

Philadelphia—Miller Fluid Power Div., 1468 York Rd., Abington, Pa. Phone Turner 4-4905

Pittsburgh—Ralph Hiller Co., 4133 Brownville Rd. Phone Tuxedo 2-7353

TEXAS

Houston—Hydraquip Corp., 6645 Navigation Blvd. Phone Walnut 6-8301

WASHINGTON

Seattle—George W. Warden Co., 1305 Dexter Ave. Phone Alder 0622 or Adams 0150

WISCONSIN

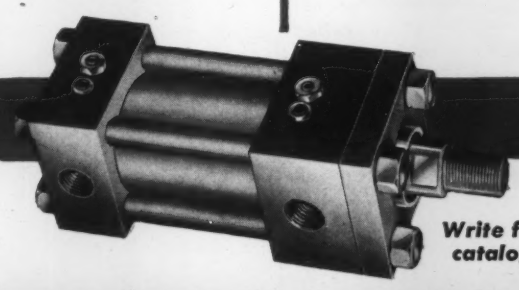
Milwaukee—Fluid Power Equipment Co., 3320 Green Bay Ave. Phone Concord 4-0046

QUEBEC, CANADA

Montreal—Miller Fluid Power Div., 520 Curzon St., St. Lambert, Montreal. Phone University 1-1304

ONTARIO, CANADA

Toronto—Miller Fluid Power Div., 4158 B. Dundas St. Phone Belmont 3-0831



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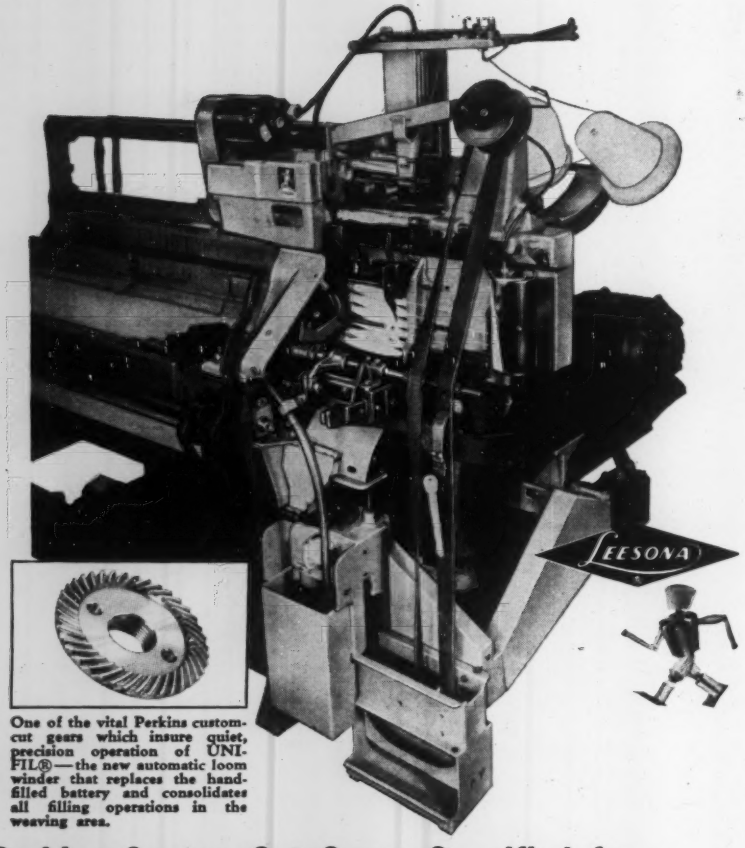

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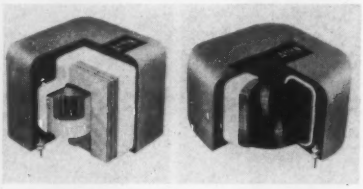


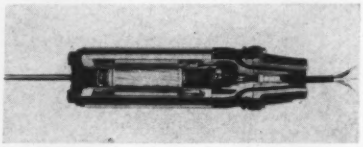
istics, as well as production quantities of standard units, are available. **ACF Industries Inc.,** Avion Div., 11 Park Place, Paramus, N. J.

Circle 732 on page 19

Submersible Motors

for oil and aqueous liquids

Line of 1/3 to ¾-hp electric motors operates fully submerged in gasoline, fuels, oils and similar liquids for high-reliability applications in remote and booster-pump systems. Oil and water types are lubricated and cooled by liquid in which they are submerged. Motors provide protection against failure from overload or low liquid level in tank. Automatic thermal protective device, located at point of fastest response, shuts off power when internal pressures rise ab-



normally. Stator windings are embedded in plastic and hermetically sealed in welded stainless-steel case for permanent protection. **Franklin Electric Co. Inc.,** East Spring St., Bluffton, Ind.

Circle 733 on page 19

Electrical Spaghetti

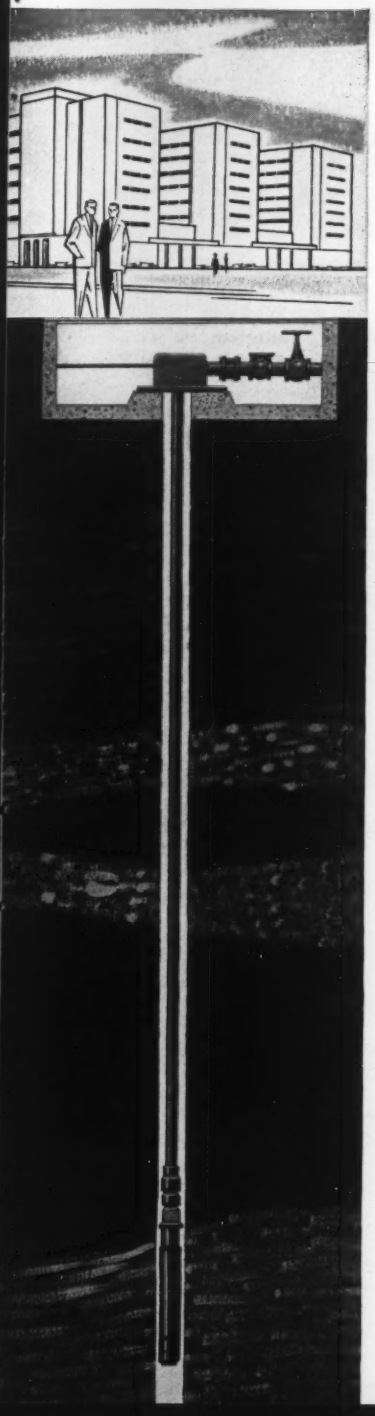
of extruded Teflon tubing

Kelon-T electrical spaghetti, for use in electrical and electronic installations as a dielectric in high-temperature service, in corrosive atmospheres or where space is at

Circle 534 on page 19

Circle 535 on page 19→

Now you can bury your pumping problems



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Water-Lubricated Submersible Pump

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Fairbanks-Morse submersible pumps permit well location anywhere that a well can be drilled. No unsightly installations, no costly pump housing. Nothing—absolutely nothing—need show above ground. These pumps submerged in the well below water level are practically soundless and require no line shafts, packing boxes or lubrication devices. Hence, wearing parts needing maintenance are reduced to a minimum. A single moving assembly does all the work.

Installation is faster and more economical. The Fairbanks-Morse motor, with lifetime Copperspun rotor cooled by water and lubricated by water, gives full motor output. The well-known Fairbanks-Morse or Pomona pump bowls are combined with these wet stator motors to produce unbeatable pumping units covering a wide range of requirements as to volume, pressure, and setting depth.

For industry or community service you can place your water service trust in the F-M submersible. Contact your Fairbanks-Morse Sales Engineer and ask him for Bulletin 6910 on this time-proved submersible pump, or write today to Fairbanks, Morse & Co., Dept. MD7-11, 600 S. Michigan Avenue, Chicago 5, Illinois.

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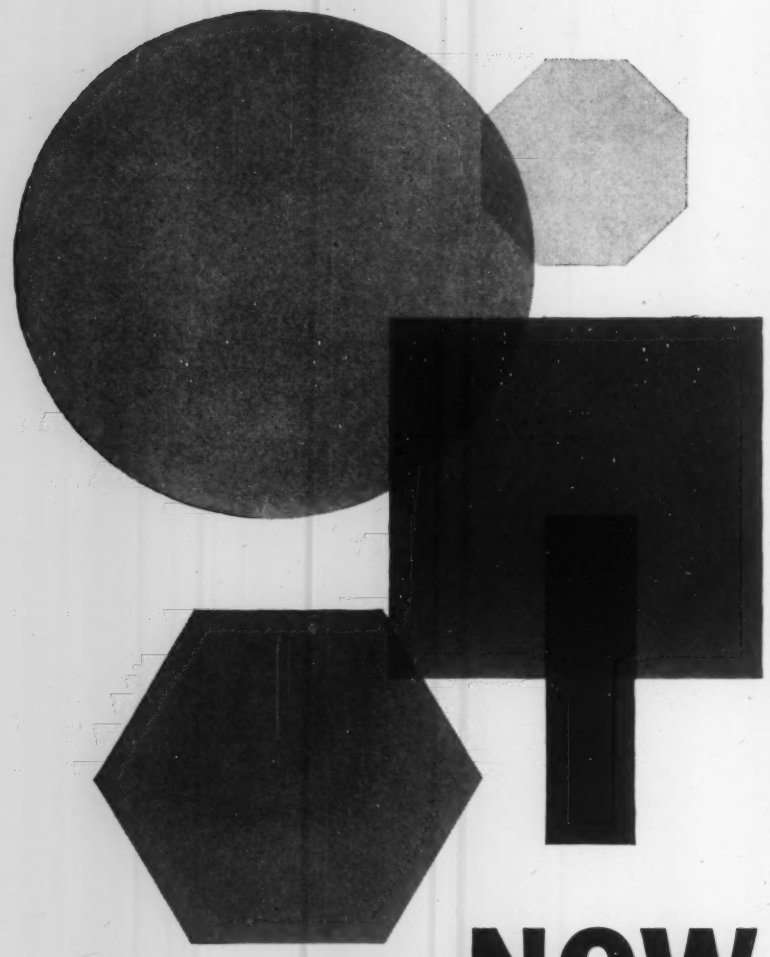

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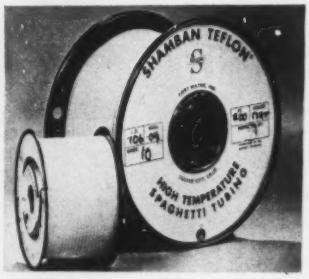
a premium, is a thin-wall extruded Teflon tubing. It is completely serviceable at temperatures from −185 to 250 C, is chemically inert, heat resistant, tough and flexible. It has excellent dielectric properties, low coefficient of friction, and zero moisture absorption. Tubing is available in AWG sizes 30



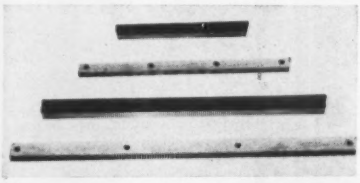
through 0 in natural and standard NEMA colors for circuit identification. It is supplied in 200-ft spools. **W. S. Shamban & Co.,** 11617 W. Jefferson Blvd., Culver City, Calif.

Circle 734 on page 19

Gear Racks

of No. 303 stainless steel and aluminum

Fine-pitch gear racks are available in 48, 64, 72, 96 and 120 AGMA Precision I pitches. They are No. 303 stainless steel and



aluminum. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, N.Y.

Circle 735 on page 19

Potentiometers

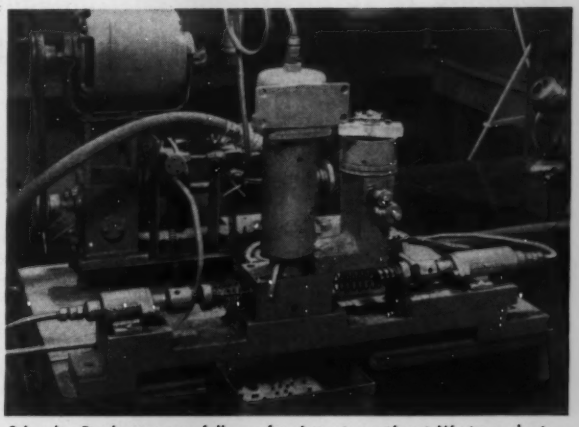
have variable depth of cup and number of taps

Modular design subminiature, miniature and standard precision potentiometers have high-temperature resistance and close linearity. Depth of cup and number of taps are variable as required by application. All mounting types are available, and ganging is permitted

***Progress** in designing air systems:*

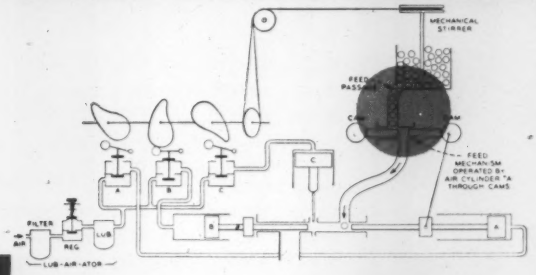
Here's another automating idea: Schrader Air Products in a multi-step punching system

PROBLEM: To pierce tiny balls of lead shot, fast, accurately, and economically.

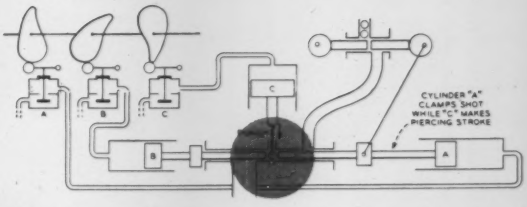


Schrader Products successfully performing at prominent Western plant—feeding, shot-piercing, ejecting—all automatically with air.

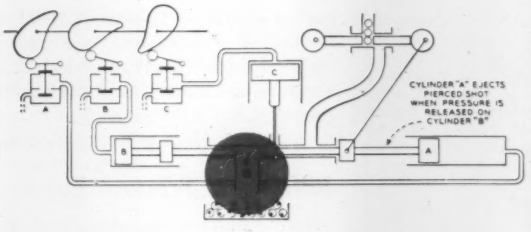
SOLUTION: Schrader Air Products designed into a system for automatic operation.



FEED: Performance of the cylinders in this system is controlled by cam-actuated Schrader valves. Cylinder A controls split-cam feed; allows the shot to be fed into the machine one at a time.



PIERCE: The shot is pushed forward and clamped at the piercing station by cylinder A and cylinder B. Cylinder C pierces the shot.



EJECT: Cylinder B returns to its initial position. Cylinder A completes its forward stroke, ejecting the pierced shot. And cycle starts again.

Air's benefits apply in almost any operation you can name: stamping, forming, programming, squeezing or measuring. And the advantages are more important today than ever: speed, accuracy, safety, simplicity, versatility, and—amazing economy. Schrader components are a natural for the designer because they comprise the only complete line of air products to select from. They can be used singly or in combination to perform jobs of amazing variety and complexity. When you design, think of air, and make use of Schrader's engineering facilities to help you specify the right products for your idea. Mail the coupon today.

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Circle 537 on page 19

(Advertisement)

Designing to total dynamic environment . . .

A NEW CONCEPT in shock and vibration protection

for missiles and jets

The total dynamic environment against which equipment must be protected in missiles and jets is so violent that protection by conventional unit isolators is impractical. Unit isolators built to meet the demands of this service would be relatively huge, yet there is no room for even admittedly inadequate present-day isolators.

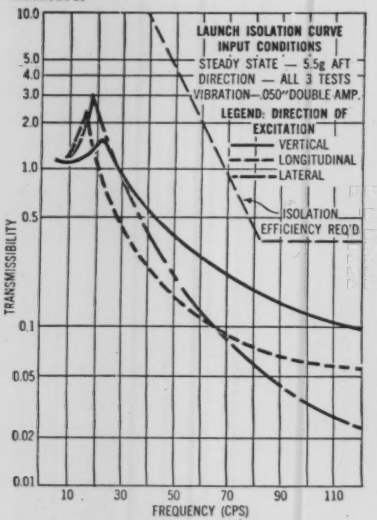


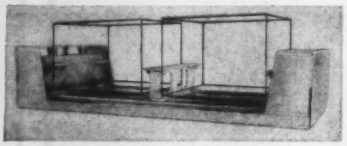
Figure 1. Graph showing specified limits of isolation efficiency during missile launching and the performance of distributed-element mounting system.

The total dynamic environment

Severe shock during launching, high *g* values of sustained acceleration with superimposed vibration, high-amplitude vibrations, and operation through all flight attitudes from horizontal to vertical — these are the elements of the dynamic environment met in currently operational missiles and detailed in the following specifications.

- Effective vibration isolation under steady-state acceleration of 6 g
- Shock transmissibility not over one for 15-g, 11-millisecond half-sine-wave shock, per Procedure I, MIL-E-5272A
- No snubber contact under high-amplitude low-frequency vibration input
- Low transmissibility at resonance
- Effective vibration isolation for all frequencies above 50 cycles per second
- Compliance with these requirements for every mounting position or attitude
- Provision of the required characteristics in an isolation system of minimum size and weight.

Obviously, MIL-spec isolators are inadequate to meet these stringent requirements.



A distributed system

A totally new design concept — a distributed-element isolation system — not only does the necessary job but provides substantial space savings as well. This is how it works. A number of small, single-degree-of-freedom, spring-and-friction-damper elements are so disposed about the mounted units that spring rates are equal for all directions of loading. This makes the isolation characteristics the same for every operating or installation position.

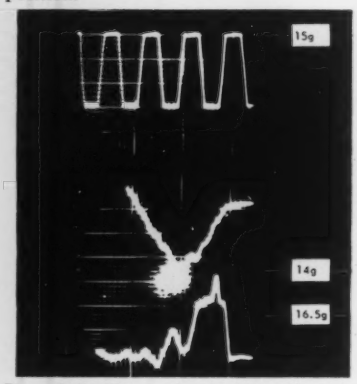


Figure 2. Oscillogram for shock test along vertical axis for an integral mounting system carrying two, six-pound electronic units. Upper trace: amplitude calibration at 60 cps. Middle trace: output from mockup of equipment. Lower trace: input to mounting assembly.

Matching the environment

With this new design concept, both the stiffness and the damping of the individual isolation elements can be selected so that the system is matched to the application. Thus it becomes feasible to provide greater shock protection in one plane, to design for different vibration inputs from different directions, or to provide whatever compensation is needed to suit the total dynamic environment. And because the separate elements can be located wherever space is available, this system minimizes space requirements.

A further advantage of this protection system is the ability to accommodate large vibration amplitudes without snubber contact. This is a result of the non-linear friction damping that can be set to limit the movement of the equipment under resonant conditions. This type of damping also allows efficient isolation of low-amplitude, high-frequency vibration because only slight damping occurs at the higher frequencies.

Additional design data

Ask for Report No. 602 giving detailed information on the specifications being met by Barry Integral Bases using the "distributed-element isolation" concept of characteristic selection.

Barry's new Western Division, in Burbank, Cal., offers fast, on-the-spot design and prototype service, and production of special systems.

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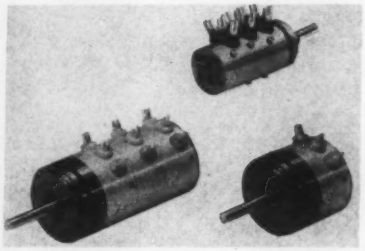
New Parts



with up to 15 cups without external clamp rings. Complete range of sizes is available. **Technology Instrument Corp.**, 537 Main St., Acton, Mass.

Circle 736 on page 19

Zippered Tubing

makes cable harness without primary fastening

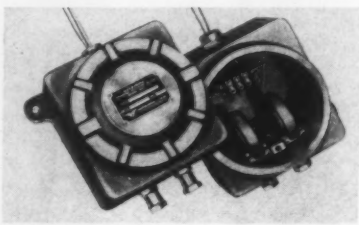
Tal-Pres flexible tube is a clear vinyl plastic material, 0.020-in. thick, which fits over and holds wire harness in position without lacing or spiral wound tape. It is available in roll form and is applied as a longitudinal covering. Seam fastening is an extrusion closed with a small, removable zipper. Closure provides a water and airtight joint which can be made permanent if desired with a liquid sealer. Material can be perforated if necessary to prevent internal condensation. It is supplied in diameters from ½ to 4 in. to fit all requirements. Black or colored tubing, perforated tubing, and thicknesses of 0.030 and 0.040-in. are also available. **Pres Industrial Equipment Ltd.**, Box 319, New Paltz, N.Y.

Circle 737 on page 19

Differential Pressure Switch

for explosive atmospheres

Model 932 switch senses a pressure difference between two variable pressures or a variable and a reference pressure. Available in four classes of proof pressures from 500



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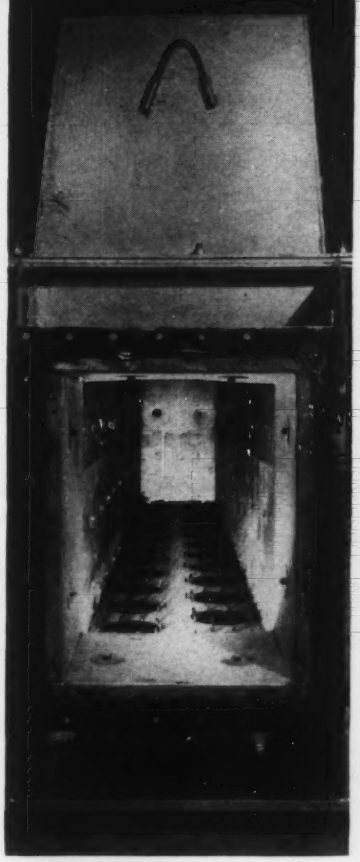
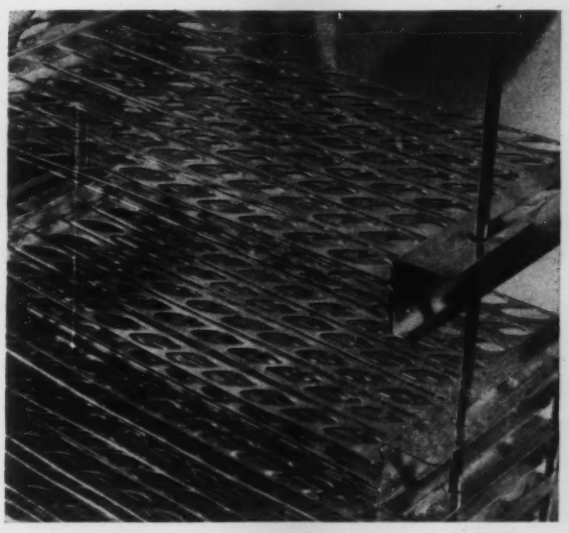
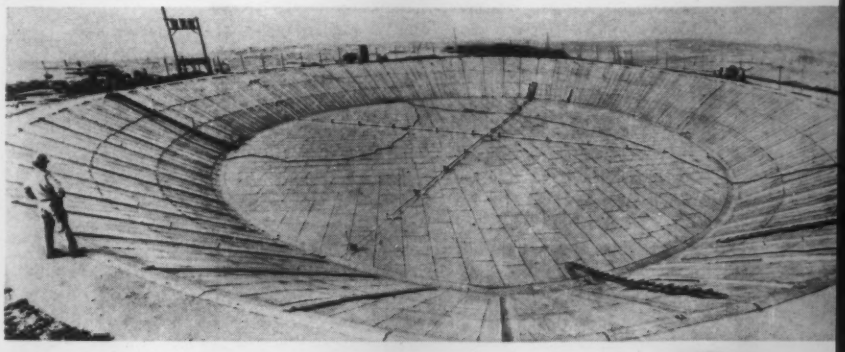


For High Temperatures. This recuperator is used on industrial furnaces. It uses waste flue gas to heat the incoming furnace air and thereby increase the efficiency of the furnace. Formerly, these recuperators were made with ceramic tubes, but heat transfer was low and leakage was high. The Hazen Engineering Company in Pittsburgh makes recuperators almost completely from Stainless Steel. Compared to ceramic designs, the Stainless design saves about 40% in fuel, increases furnace output about 10%-15%. The Stainless Steel performs well, even at this 1800-2300° F. temperature range.



For Cleanliness. When you work near nuclear radiation areas, you wear a small badge containing X-ray film that records how much radiation you have received. The film, "photodosimetric film," is developed in a Sensitometric Processing Unit made by Bar-Ray Products, Inc., in Brooklyn. The unit, including the trays shown here, is made completely from 18-gage Type 316 Stainless Steel because it resists corrosion, is easy to clean, has a hard, dense surface that doesn't harbor dirt.

For Corrosion Resistance. The Hercules Powder Company needed an ammonium nitrate storage tank for their plant near Richmond, California. They took an old, World War I concrete reservoir and lined it with Type 304 USS Stainless Steel. The 14-gage sheets are laced with 18,000 feet of vacuum-tested welds. Tank holds two **million** gallons of solution, and is 200 feet in diameter at the top. U. S. Steel's Consolidated Western Division handled the complete installation.



United States Steel Corporation, Pittsburgh • American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco • National Tube Division, Pittsburgh
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UNITED STATES STEEL

Circle 539 on page 19

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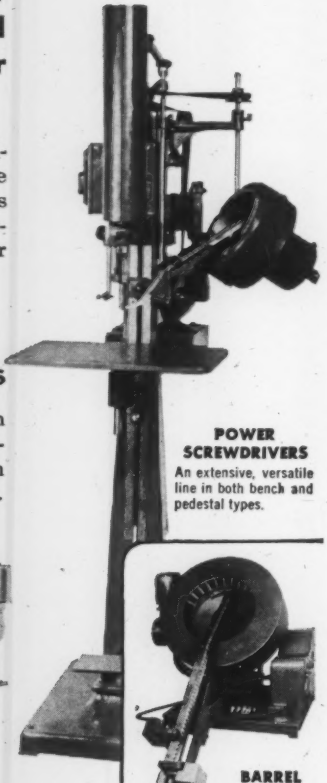
equipment can be selected, and custom features incorporated, to fit your requirements. Plan now to use DPS modern assembling methods. Tell us your set-up. Write for catalog and further details.



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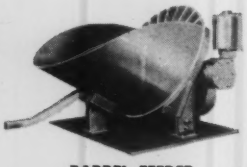
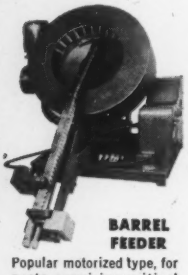
BOWL FEEDER
Electrical vibratory type to feed parts that cannot be tumbled.



BARREL FEEDER
with stationary ring cover for heavy-duty production.



BARREL FEEDER
Popular motorized type, for parts requiring critical selection.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT STREET DETROIT 16, MICHIGAN

New Parts

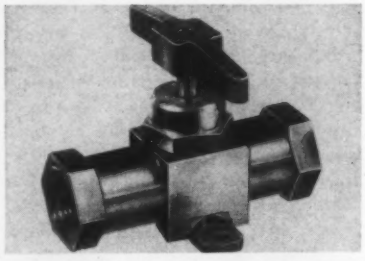
to 12,000 psi, switch permits opening or closing a circuit on increasing or decreasing pressure difference from 15 to 10,000 psi at any point within adjustable range of model. Two parallel Bourdon tube sensing elements provide extreme repetitive accuracy. Unit operates in any position, with no balancing or leveling necessary. It is used for operating relays, solenoids, motor control and other similar devices. Mechanism is housed in an explosionproof enclosure. **Barksdale Valves,** Pressure Switch Div., 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 738 on page 19

Control Valve

has zero leakage from 500 to 3000 psi

Straight-through, ball-valve, directional-control valve is used with pneumatic, most fuel and hydraulic oil systems, and for most liquid or gaseous propellants. When used



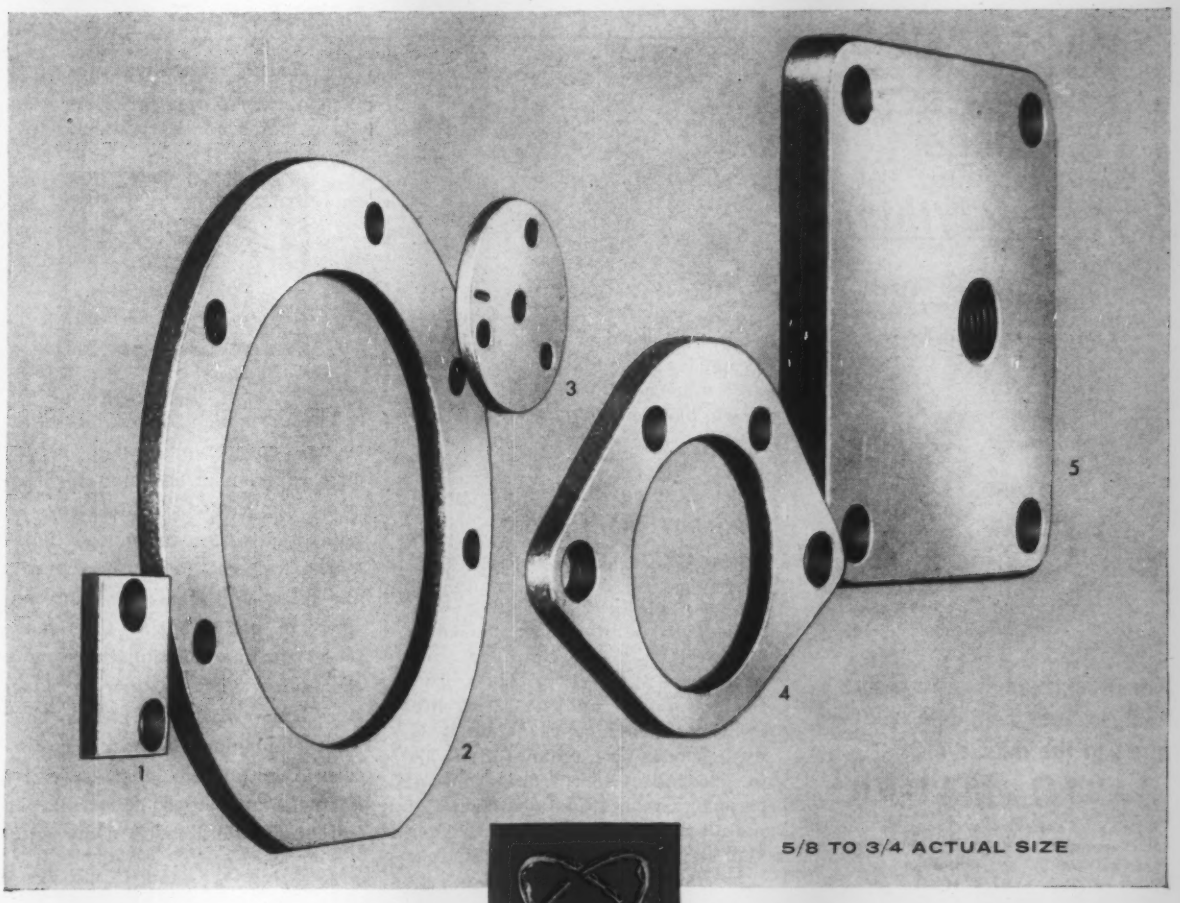
as control valve for emergency air start for jet engines, valve measures only 3½ in. long by less than 1½ in. high, and has maximum operating torque of 20 lb-in. With zero leakage from 500 to 3000 psi, unit meets MIL specs for shock and vibration. **Eastern Aircraft Products Corp.,** Orange, N.J.

Circle 739 on page 19

Plastic Coil Forms

in wall thicknesses from 0.002 to 0.010-in.

Mylar thin-wall coil forms are highly resistant to moisture, solvents and chemicals and have high dielectric strength. They provide excellent thermal characteristics, have high tensile strength, and do not dry or brittle with age. Wall thicknesses from 0.002 to 0.010-in.



From the producer of piston rings used in 1 out of every 3 new cars . . .

"Captive Cost" castings-precision finished and machined

Muskegon's Sparta Foundry now offers these important advantages in the production of your small precision castings.

1) Parts at surprisingly low cost.
2) Complete service from design conception to finished product.
3) Precision cast parts in rough form, partly finished or shipped ready-to-install—completely deburred, drilled, reamed or tapped . . . with surface finishes and flatness to your specifications.
4) Choice of any metal, including latest sintered powdered metals.

(1) Automatic transmission governor cover plate.
(2) Countershaft retaining ring.
(3) Compressor thrust plate.
(4) Camshaft attaching plate.
(5) Oil filler cover.

GET YOUR FREE SAMPLE KIT!
Here's an assortment of miniature iron and bronze sand castings and sintered powdered metal parts that shows how Sparta can reduce or completely eliminate your finishing and machining operation. Write Sparta Foundry Co., Sparta, Mich.

MUSKEGON Piston Ring Co.
PLANTS AT MUSKEGON, MICHIGAN SPARTA, MICHIGAN
ROTARY SEAL DIVISION PLANTS AT SPARTA, MICHIGAN CHICAGO, ILLINOIS

Since 1921... The engine builders' source!

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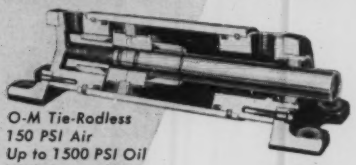
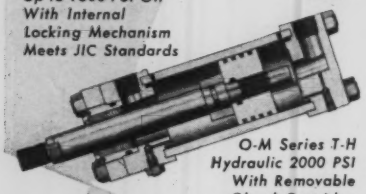
(AIR AND HYDRAULIC)
have everything



O-M Tie-Rodless
150 PSI Air
Up to 1500 PSI Oil
With Internal
Locking Mechanism
Meets JIC Standards



O-M Series T-H
Hydraulic 2000 PSI
With Removable
Gland Cartridge
Meets JIC Standards

Construction and performance features that keep O-M cylinders right in the middle of...

AUTO-MATION

- Smooth, dependable operation at all practical speeds.
- Precision-honed, seamless steel body.
- Shock and vibration resistant.
- High-tensile alloy steel piston rod—ground, polished and hard-chrome plated.
- Multiple lip, self-compensating rod gland packing on all hydraulic cylinders.
- Self-compensating piston and rod packing on all cylinders, with packings available for fire-resistant fluids, also wide temperature ranges.
- Machined bearing bronze bushings for maximum service with minimum friction.
- O-ring static seals throughout with no flat gaskets to leak.
- Efficient wipers or scrapers on piston rods.
- Rolled steel precision machined end caps with ample sized ports.
- Adjusting needle for cushion control with ball checks for rapid full power starts.
- Versatile port orientation.
- Wide range of mounts and mounting accessories available.
- Easily maintained—parts subject to wear can be repaired with minimum downtime.
- Plus many other features.

O-M Air and Hydraulic Cylinders are available in 1½" to 8" bores with standard and heavy-duty piston rods.
Mail coupon today for Bulletins 101A (O-M Tie-Rodless Cylinders) and 105 (O-M Series T-H Hydraulic Cylinders).

ORTMAN-MILLER MACHINE CO.
7 143rd Street, Hammond, Indiana
☐ Have representative call
☐ Send Bulletins 101A and 105
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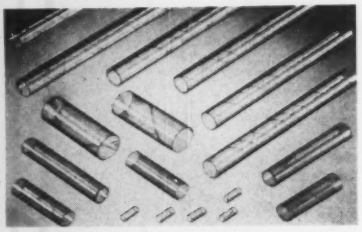
Circle 542 on page 19

New Parts



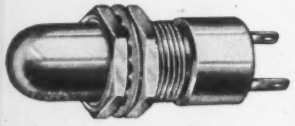
are available in any OD, ID or length. Coil forms are suitable for compact and miniature assemblies. **Precision Paper Tube Co.,** Dept. MDC, 2035 W. Charleston St., Chicago 44, Ill.

Circle 740 on page 19

Miniature Pilot Light

uses neon glow lamp

Dialco pilot light uses flange-base neon glow lamp which measures about ⅜ by ¼-in. Lamp consumes about 0.04-w power, produces practically no heat, and has long life. Pilot light housing the lamp is ¾ by 1¼ in. in size, mounts in 17/32-in. clearance hole from front of panel. Stovepipe-shaped cap of high-heat plastic provides 180 deg visibility. It is available in four colors or clear. Metal parts are



brass with black nickel, white nickel or chrome finish. Terminals are perforated for wire. Phenolic material of military specification grade provides insulation. **Dialight Corp.,** 60 Stewart Ave., Brooklyn 37, N.Y.

Circle 741 on page 19

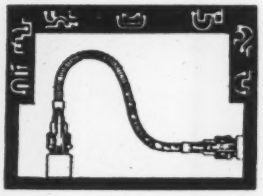
Speed Detector

self-contained unit is for flange mounting

Syncro-Pak self-contained speed-detecting device can be flange mounted in any location. It is dust tight and provides its own shaft mounted in ball bearings. Shaft can be coupled to the shaft of equipment to be protected or controlled. Unit incorporates almost any required combination of sensing switches to detect over-

FLEXIBLE SHAFTS

Handle wide variety of control applications.



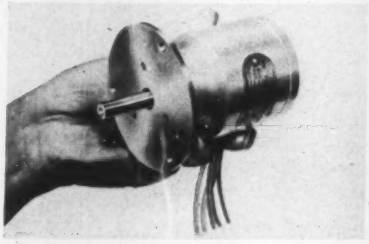
The Flexible Shaft today, although not complicated, is a specific component designed for specific applications. Industry in many fields, i.e., automotive, automation, aircraft, electronics, radio and television, machinery, and marine (to name but a few) have found flexible shafting to be more economical and yet more productive than whatever means they were employing to control motion from one unit to another where obstacles in the path of installation were impossible to do away with.

There are two types of flexible shafts. One is the power drive flexible shaft which utilizes a cable wound to rotate in one direction only. The outer layer of wire of the cable determines the direction rotation, and is wound so that the slack is taken up when the shaft is in operation, making it practically impossible for the cable to spring from its original shape. The other type is the remote control flexible shaft in which the cable is wound so that the slack is taken up no matter which direction the shaft is turned. The remote control shaft provides for both rotation and reciprocation, such as the opening and closing of a valve.

●●● For complete information as to how flexible shafting may help you solve your specific control problem, write F. W. Stewart Corporation, 4311-13 Ravenswood Ave., Chicago 13, Illinois.

Circle 543 on page 19

speed and underspeed in a narrow or wide range. It is adaptable for use on conveyor and similar drives to indicate slippage or to actuate magnetic clutches, and also provides a method of shifting multi-



speed transmission gears. Shown is two-stage unit rated at 5 amp and accurate to ±1 per cent. **Torq Engineered Products Inc.,** 32 W. Monroe St., Bedford, O.

Circle 742 on page 19

Thermal Switch

protects against excessive overheating

Heat limiter protects many types of electrical devices or apparatus against excessive overheating. Switch opens the circuit should temperature at thermal cut-out rise above its set point. Unit can be installed in heater-element circuit or relay circuit. It is avail-

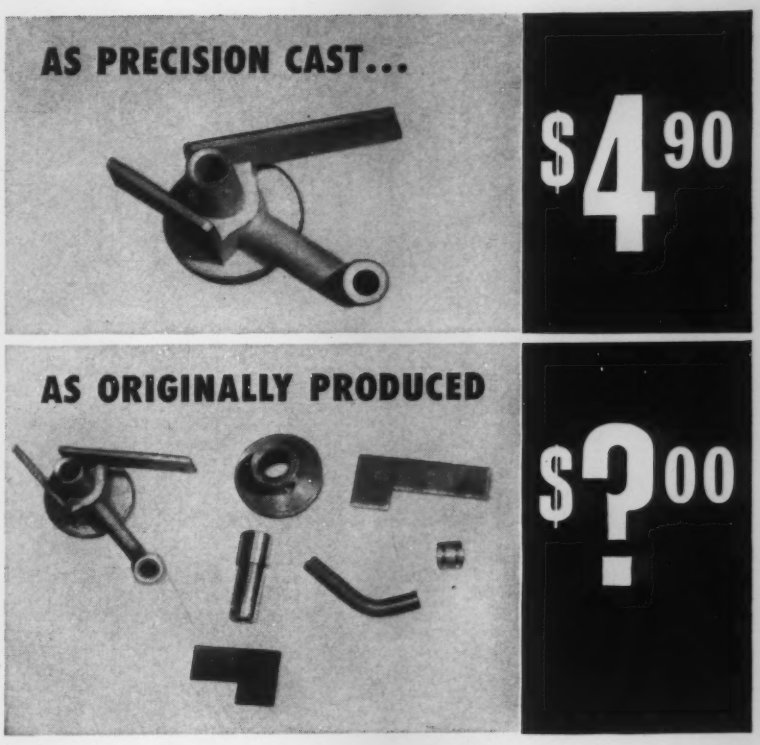
able in many types and styles of terminals. **McGraw-Edison Co.,** Bussman Mfg. Div., University at Jefferson, St. Louis 7, Mo.

Circle 743 on page 19

Relief-Valve Actuator

has wide range of speeds

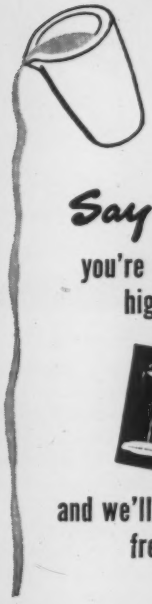
Relief-valve motorized actuator is for direct mounting on a relief valve in place of hand adjustment. It can be furnished with two-speed control to provide ease and ac-



Precision Metalsmiths casts this valve as a pressure-tight unit in a beryllium copper alloy at the unbelievably low cost of $4.90.

Figure what it would cost—at your overhead—to produce, handle and stock the six brass, copper and steel parts that formerly went into this assembly. Then add fabrication costs, with an allowance for leaker-rejects that showed up all too frequently.

We can't promise you savings like this, of course. But the expendable pattern process gives product designers a free rein; your men *imagine* what they'd like to have and we cast it for them. Many machining and assembly operations can be eliminated and, often, parts are made in alloys that can't be machined—a fraction of an ounce up to 10 pounds.



Say "when" you're worried about high costs

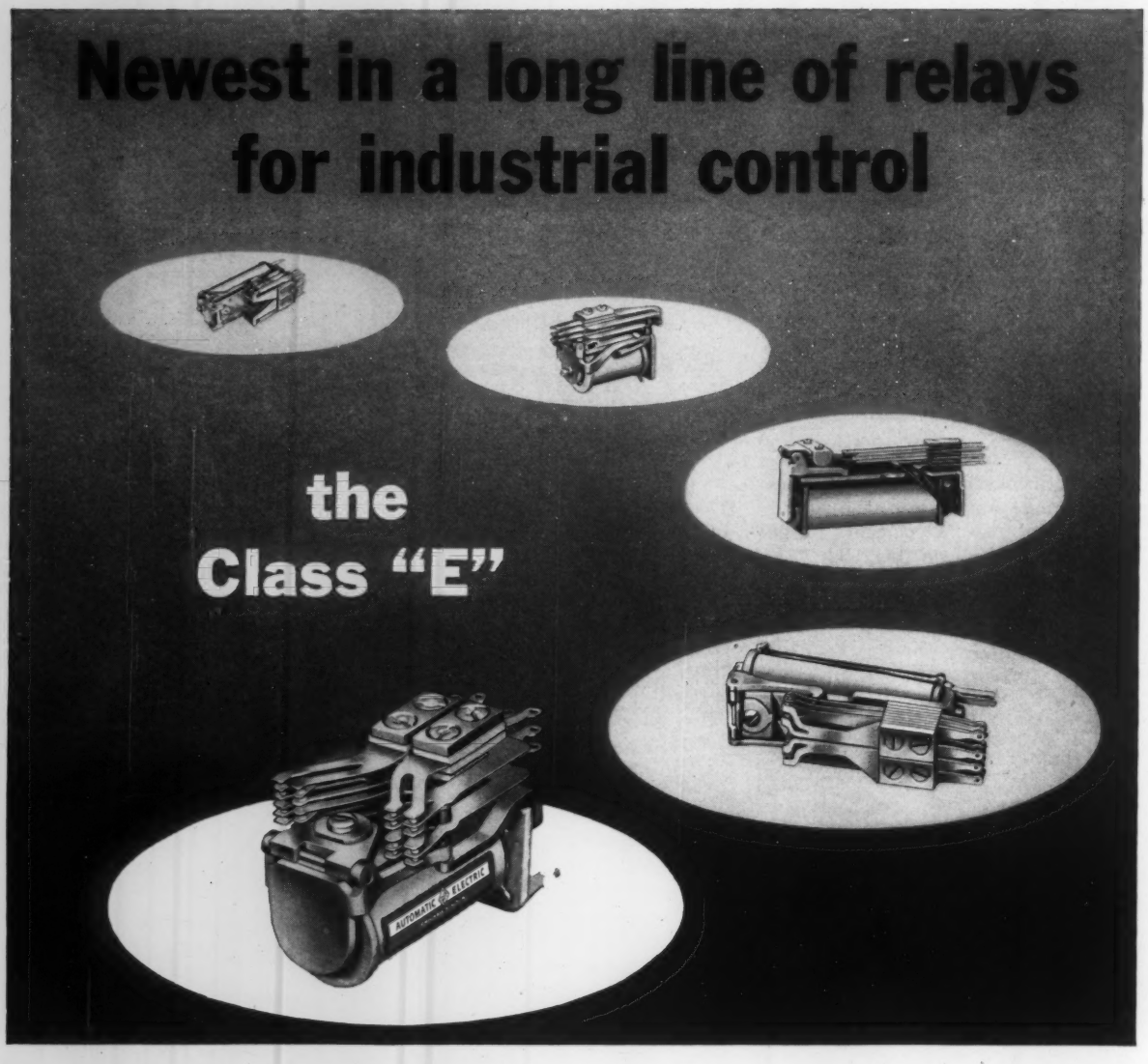
and we'll send you this free book

PRECISION METALSMITHS, INC., 1083 East 200th St., Cleveland 17, Ohio

pour yourself an assembly with
PRECISION METALSMITHS INC.
INVESTMENT CASTINGS

Circle 544 on page 19

Newest in a long line of relays for industrial control



This is the relay you've asked us to build. Now Automatic Electric is happy to present its latest achievement—the miniature Class "E". We're proud because this husky baby brother of the Class "B" condenses all of its famous features in a minimum of space and weight . . . with no sacrifice of quality! Many Class "E" features appear for the first time in a relay of such compact size. Here's a relay which is indispensable where small size and weight (coupled with reliable performance) are of prime importance.

This new miniature relay comes to you with a solid reputation, backed by 65 years of leadership in automatic dial telephone equipment for America's Independent telephone companies and leadership in industrial controls for industry.

Check these features of the new Class "E"—

- miniaturized, telephone-style, base mounting for rear-connected wiring.
- heavy thickness armature arms (previously available only in larger relays).
- heavy-duty backstop that won't wear out.
- adequate terminal clearances for easy wiring.
- long-life, lubricant-retaining bearing also allows for an easy check of the heelpiece airline setting, without disturbing the adjustment.
- fully independent twin contact springs.
- sturdy, strain-relieved heelpiece insures stability of adjustment.

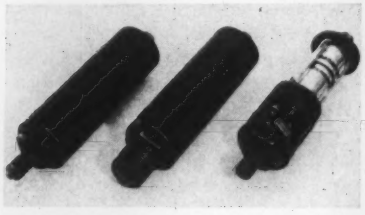
For more information, call or write Automatic Electric Sales Corporation, Northlake, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

A member of the General Telephone System—
One of America's great communications systems

GENERAL TELEPHONE SYSTEM

Circle 545 on page 19



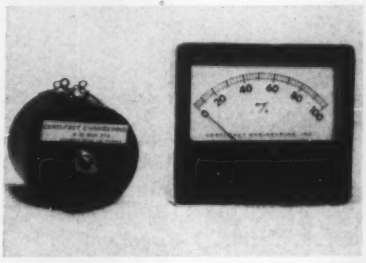
curacy of setting. Limit switches are included for normally open and closed limit settings. Wide range of actuator speeds is available to provide any desired time for full-stroke actuation. Standard motor voltage is 28 v dc. Other voltages can be accommodated by changes in motor or control box. **United Hydraulics Inc.,** Dayton, O.

Circle 744 on page 19

Transmitter and Receiver

for remote indication of angular position

Matched transmitter-receiver pair are used for remote indication of angular position. Transmitter gives a linear output over 320-deg range. Unlimited number of receivers can be connected in parallel to one transmitter without reduction of standard 3 per cent accuracy. Receiver has provisions for zeroing



in at upper and lower limits of scale. Power requirement is 110-120 v, 60 cycles. Receiver requires only two wires from transmitter. **Certi-Fact Engineering Inc.,** P. O. Box 774, Sherman Oaks, Calif.

Circle 745 on page 19

Fractional-Horsepower Motors

in NEMA frames 56 and 48

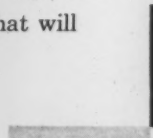
Model R rerated fractional-horsepower motors, available in ratings from ⅛ to 1 hp in polyphase, capacitor single-phase, permanent split-capacitor and split - phase

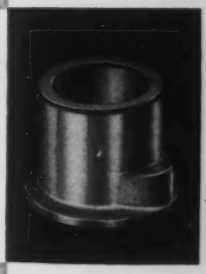
time to re-examine

BEARING APPLICATIONS

Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

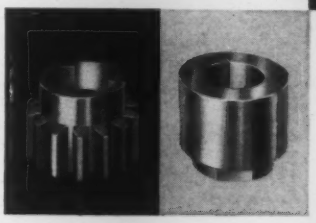
Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.





A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.



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BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

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Circle 546 on page 19

Mr. Design Engineer –

Here are BRAND NEW units for improving efficiency of pneumatic operation

— new designs
— new features
— new **HIGH EFFICIENCY**

(introduced by WATTS, leader in flow control specialties since 1875)

Delivers really CLEAN dry air

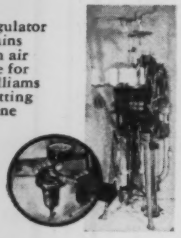
Watts Filter delivers clean dry air to Federal Products Dimensionair.

High-Efficiency FILTER with exclusive "Tornado Action."

Extreme centrifugal force spirals dirt and moisture particles downward into the "quiet zone" leaving in the air only a minute percentage of the finest and lightest particles which are trapped by the filter cone.

Maintains MORE UNIFORM PRESSURE

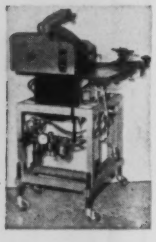
Watts Regulator maintains uniform air pressure for Scott-Williams KN Knitting Machine



High-Efficiency REGULATOR with highly sensitive "Aspirator Action."

Watts Aspirator control acts directly on the diaphragm, giving instant compensation for fluctuating pressure demands . . . provides precise control and stabilizes pressures reaching individual pieces of equipment.

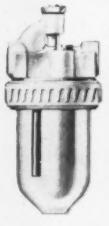
LUBRICATES perfectly at all flow rates



Watts Lubricator provides efficient lubrication for Markem Machine Company's Model 70AF.

High-Efficiency LUBRICATOR with exclusive "By-pass pick-up."

Watts new By-Pass Pick-Up makes possible a sub-miniature, high velocity venturi section which positively creates sufficient force — even at flow rates as low as one cubic foot per minute — to vaporize oil into a fine mist for uniform, economical lubrication.



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get the facts on Watts new-design units which open up new worlds of efficiency in Pneumatic Operation, Line Maintenance, and Protection of Equipment against foreign matter.

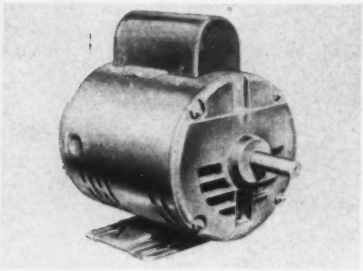
REQUEST CATALOG AND DETAILED SPECIFICATION SHEETS

WATTS REGULATOR COMPANY
SINCE 1875

12 EMBANKMENT ROAD — LAWRENCE, MASSACHUSETTS

New Parts

types, are designed in NEMA frames 56 and 48. Reductions in weight and size are effected by use of aluminum rather than cast iron and improved design application of copper and steel. Motors are available with either sleeve or fully sealed ball bearings. Sleeve bearings are lubricated by wool-felt packing system which retains lubricant regardless of operating position. Units have either rigid,



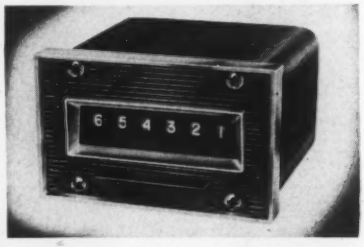
welded base or vibrationless, resilient rubber mounting. Totally enclosed fan-cooled or totally enclosed nonventilated construction is available. **Robbins & Myers Inc.**, Springfield, O.

Circle 746 on page 19

Electromechanical Counter

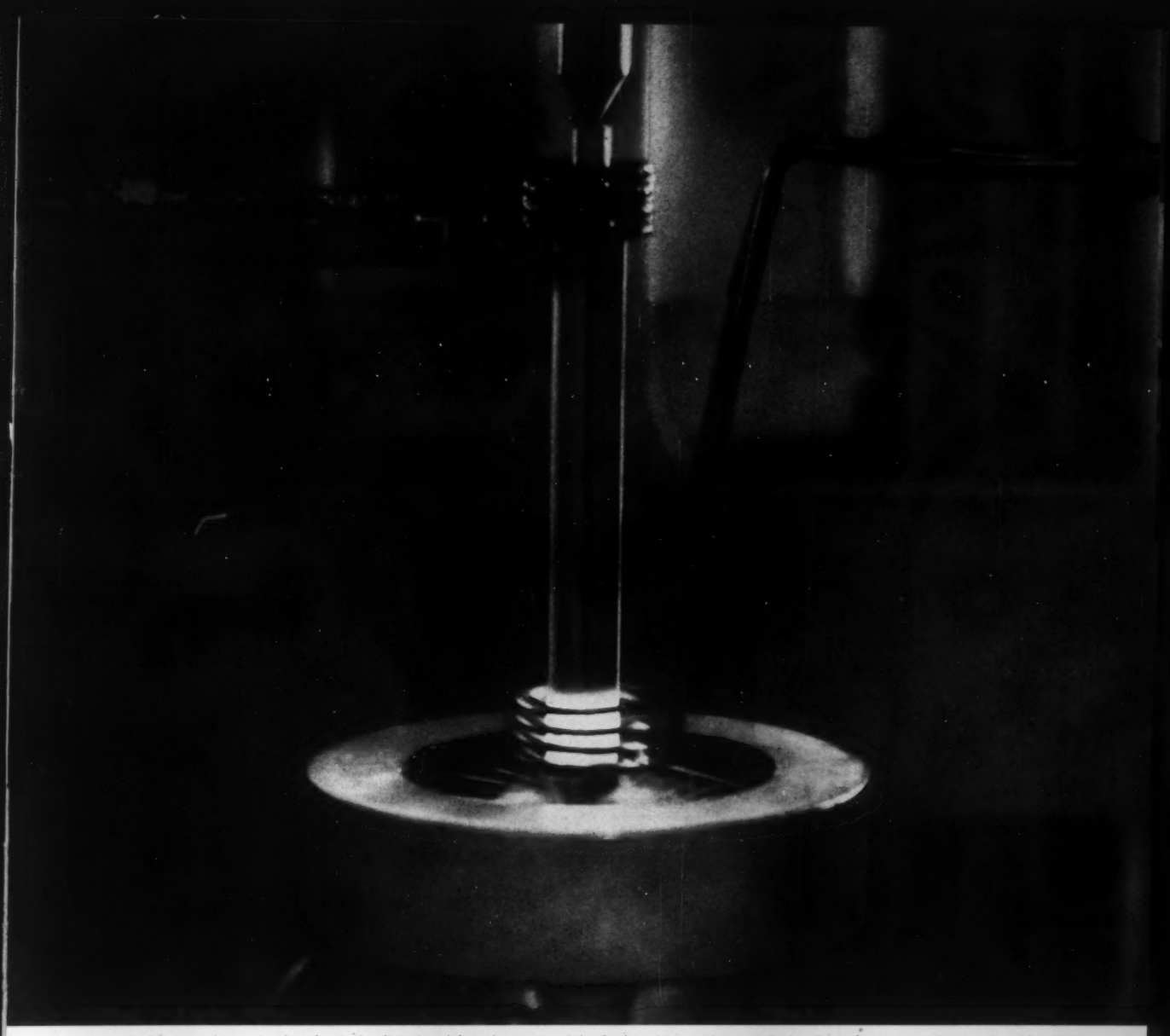
has count rate to 60 per second

Neuron counter adds, subtracts and totalizes. It has a life of 300 million counts, count rate to 60 per second, electrical or manual reset by single-stroke push bar, and switch readout circuitry for accurate programming. Counter uses etched circuitry in place of internal wiring. Bidirectional stepping mechanism is locked between



impulses to prevent double indexing due to shock, vibration or overvoltage. Unit is available in four models to accommodate a variety of counting problems. It is for applications where counting of ar-

Circle 547 on page 19



Ketos shaft being induction hardened to Rockwell 55-56, while ends remain soft for final machining. Photographed at Control Instrument Co., Inc., Brooklyn, N. Y.

KETOS has wide hardening range with minimum volume change...

Ketos is a low priced alloy tool steel that can be hardened from low temperatures with practically no volume change. It has deep hardening qualities, and a fine grained structure, that make it desirable for many production parts.

That's why nondeforming Ketos is well suited not only for most tool steel applications such as gauges, dies, and taps but also for close-tolerance, wear-resistant parts like the actuator bar shown in the induction heating unit above. The thin contact edges of this particular part withstood a "life test" of over 4-million high speed blows. No other steel tested lasted more than 1-million cycles before it chipped and failed.

If Ketos sounds like the steel you should be using, call your nearby Crucible warehouse. Stocks of Ketos and dozens of other special tool steels are large, delivery fast. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

Circle 548 on page 19

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both ends of circuit—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for Steam, Oxygen, Acetylene, etc.

REPRESENTATIVES IN PRINCIPAL CITIES

SINCE 1915 ® QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

New Parts

ticles moving at high speeds is required, or where timekeeping or accurate measurement of rapid flow is necessary. **Autron Engineering,** 1254 W. 6th St., Los Angeles 17, Calif.

Circle 747 on page 19

Glass Epoxy Laminate

is flame retardant

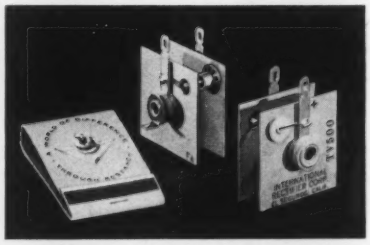
Glass epoxy laminate will not continue to burn when removed from a flame because of self-extinguishing characteristics imparted by flame-retardant additives. Having high strength and good electrical properties, laminate is heat resistant and can be used continuously at temperatures to 300 F. It is available in plain form for power applications and metal clad form for printed circuitry. Material is available in sheets 0.010 to 1 in. thick. Applications include switchgear components, panels, terminal boards and other power equipment, and radio and television relays, printed-circuit panels and other electronic components. **Continental - Diamond Fibre Corp.,** Newark, Del.

Circle 748 on page 19

Silicon Rectifier

for television use

Unistac TV500 silicon rectifier is a direct and universal replacement unit for all selenium stacks up to 500 ma. Having eyelet construction, it eliminates need for special sock-



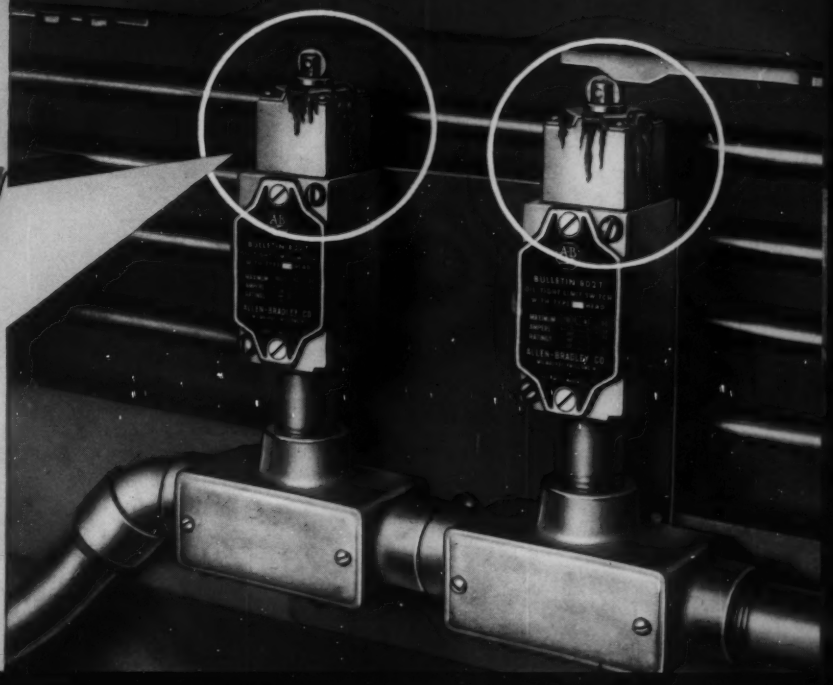
ets, drilling or conversion kits. Silicon diode mounted on finned heat exchanger provides convection cooling. One unit in a half-wave circuit delivers 500 ma and 130 v dc, with input voltage of 117 v rms. **International Rectifier Corp.,** 1521 E. Grand Ave., El Segundo, Calif.

Circle 749 on page 19

Circle 549 on page 19

Circle 550 on page 19→

Completely Oil-Sealed!



A-B QUALITY

802TC Side Push Rod Type

802TF Rod Type

802TA Roller Lever Type

802TB Top Push Rod Type with Plastic Window

802TAO Roller Lever Type for Cavity Mounting

802TG Adjustable Roller Lever Type

SEALED HEAD KEEPS OUT OIL, COOLANT, METAL CHIPS

...your guarantee of reliable limit switch operation!

With *completely sealed* operating heads, as well as sealed switch bodies, Allen-Bradley Bulletin 802T oiltight limit switches provide maximum reliability in limit switch operation for your modern, high speed production machines. The sealed head excludes oil, dirt, and metal chips from the operating mechanism... the spring return, momentary contact operators cannot become sluggish and stick.

The maintenance free, double break, silver alloy contacts are sealed in the oiltight body. Interchangeable operating heads are available with various push rods and levers which can be mounted in any one of four positions. Oiltight transparent plastic covers, for inspecting contacts and wiring without removing the cover, are available for most units.

Here's a line of *quality* limit switches in which each type will provide millions of trouble free operations. Have your A-B control engineer acquaint you with this latest development—another advance in limit switch design.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

9-57-MR

NOW... ALLEN-BRADLEY PRECISION-TYPE LIMIT SWITCHES ARE ALSO OILTIGHT!

OILTIGHT HEAD Newly designed head on push type seals out oil. Roller lever types have sealed operating shafts.

OILTIGHT BODY Synthetic rubber gasket between housing and plate excludes oil and coolant from operating mechanism.

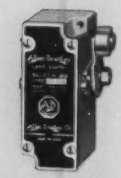
Allen-Bradley precision-type limit switches combine very close operating tolerances with such a sturdy construction that they can be used for any industrial application. Now this line of limit switches has been further improved by making them completely oiltight.

Especially designed for use where the motion to operate the limit switch is measured in thousandths of an inch, these Allen-Bradley limit switches can henceforth be employed in applications where oils, coolants, and dust are present.

Allen-Bradley Bulletin 802 oiltight precision limit switches have a positive snap action mechanism which prevents any possibility of a "dead center" . . . no matter how slowly the actuating force is applied. They are available in both the spring return and maintained contact construction. And all have maintenance free, double break, silver alloy contacts.

Specify these Allen-Bradley oiltight limit switches where "precision" operation is required and where dirt and oil could cause trouble.

Push rod type. Plastic cover, for inspection without removing cover, made for most units.



Roller lever type limit switch with lever on right side. Also available with lever on left side.

Roller lever precision-type limit switch with roller lever in front of the switch body.

ALSO—GENERAL PURPOSE LIMIT SWITCHES

Bulletin 801 general purpose limit switches in standard or heavy duty ratings. Maintained or momentary contacts with slow or snap action. Silver alloy contacts used throughout this line.

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MOTOR CONTROL
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A-B QUALITY

9-57-MR

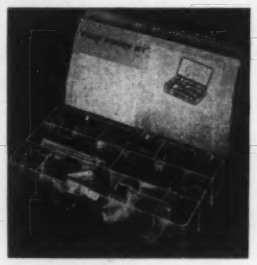
ENGINEERING DEPARTMENT

EQUIPMENT

Stack-Switch Kit

contains all stack-switch assembly components

Stack-switch kit contains contact spring blades in various thicknesses, silver contact points, phenolic spacers, insulating tubing, brackets, screws and assembly pins. Two sets of stack assembling pins are furnished with each



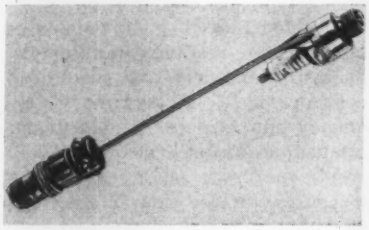
kit. Larger set of pins is used to assemble switch leaves and insulating spacers with mounting centers of ⅜-in. and smaller set is used for assembling ¼-in. center leaves and spacers. **Switchcraft Inc.**, 1328 N. Halsted St., Chicago 22, Ill.

Circle 750 on page 19

Pressure Pickup

is built into body of functional spark plug

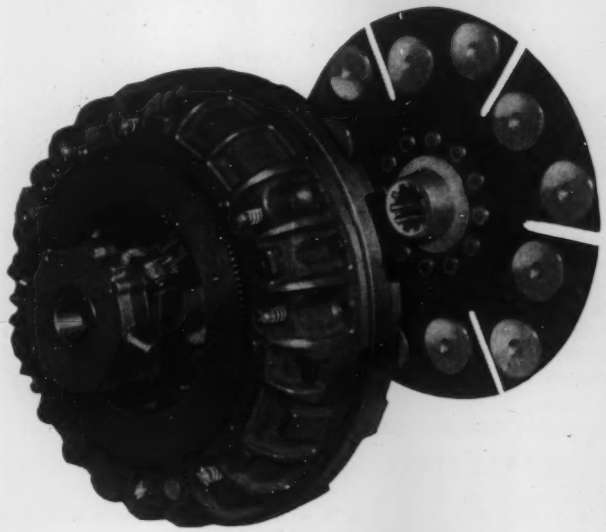
Pressure pickup, installed in body of standard spark plug, retains thermal, ignition and physical characteristics of the plug. It is used for development, testing and



maintenance of internal combustion engines and study of fuels, carburetion and detonation. Unit

ROCKFORD

OVER-CENTER CLUTCHES



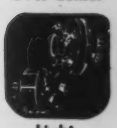
Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center



Light Over Center

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Speed Reducers

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HIGH TORQUE
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ENGINEERING B-W PRODUCTION

CLUTCHES

Circle 551 on page 19

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Circle 552 on page 19

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Circle 553 on page 19

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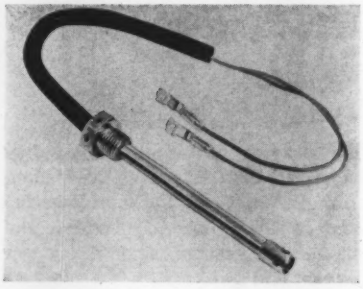
permits extensive tests and studies on production-model engines under actual operating conditions. Device is capable of high-frequency performance and provides full record of engine pressure cycles at low or high speeds. Units incorporate standard 14 mm spark plugs and have pressure range of 0 to 1000 psi. They can be used in water or air-cooled engines. **Dynamic Instrument Co. Inc.,** 28 Carleton St., Cambridge, Mass.

Circle 751 on page 19

Temperature Probes

for low-temperature use

S-100 temperature probes are designed for precise measurements at very low temperatures. They measure temperature changes for applications such as liquid-oxygen systems, guided missiles and com-



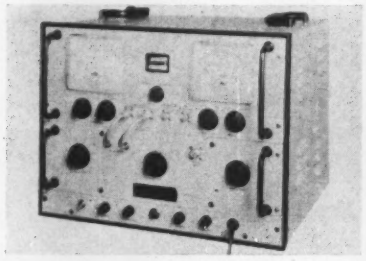
ponents in electronic circuits. Probes, incorporating thermistors mounted in probes of stainless steel, aluminum, lucite or other material, can be used with temperature bridges or recorders. **Gulton Industries,** 212 Durham Ave., Metuchen, N. J.

Circle 752 on page 19

Microwave Stability Tester

measures stability of microwave oscillators

With Model 5004 microwave stability tester, readings can be taken instantaneously and monitored continuously. Disturbance frequency can also be displayed and studied on an oscilloscope. At S-band, frequency changes can be measured to less than 2 cps. Instrument measures drift and rate of drift, and displays information on two large meters. It covers entire range of microwave frequen-



cies from L through X-band, using interchangeable heads. **Laboratory for Electronics Inc.**, 75 Pitts St., Boston 14, Mass.

Circle 753 on page 19

Mounted Paper

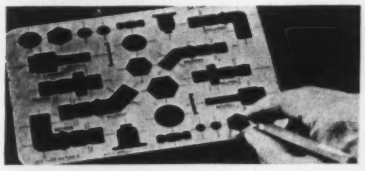
of moisture-resistant, opaque film

Stabilene opaque drawing surface Mylar film is fully resistant to moisture, will not smudge and can be wiped clean with moist cloth. It has excellent dimensional stability, and takes pencil and ink well without feathering, penetration or ghosting, even after erasures have been made. Material is 0.0075-in. thick, and is very firm. It is available in three colors, and sheets can be supplied with preprinted title blocks or borders. **Keuffel & Esser Co.**, Adams St., Hoboken, N.J.

Circle 754 on page 19

Drafting Templates

for layout of MS flareless fluid fittings



Five drafting templates permit rapid and accurate visualization of MS flareless fluid fittings to determine space requirements without trial and error. Templates are 0.025-in. amber-coated vinyl plastic. They contain cutouts for 3/16 and 5/16-in. tube sizes, ¼ and ⅜-in. sizes, ½-in., ⅝-in. and ¾-in. sizes. Corresponding MS part number is shown opposite each cutout. **E. F. Twomey Co. Inc.**, P. O. Box 15913, Los Angeles 15, Calif.

Circle 755 on page 19

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"NO loss of time," say the thousands of users of LAMINUM SHIMS...

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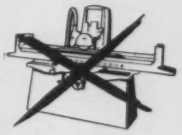
NO grinding!



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Circle 554 on page 19

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THE ENGINEER'S Library

Recent Books

Magnetic Amplifier Circuits. *By William A. Geyger, U. S. Naval Ordnance Laboratory; 394 pages, 6½ by 9½ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York, N. Y.; available from* MACHINE DESIGN, *$7.00 postpaid.*

The treatment of magnetic-amplifier circuits in this second edition has been considerably revised and enlarged to include new developments and applications in this field.

The book is a practical exposition of the fundamental principles, characteristics, and applications of magnetic-amplifier circuits. It develops the various kinds of basic and more complex circuit arrangements, with as much emphasis as feasible on experimentally observed phenomena. Extended mathematical considerations and proofs are avoided. Descriptive and graphical methods give a qualitative and quantitative interpretation of essential facts.

The book is written for the circuit designer and its material is classified according to circuit functions.

A partial list of features includes expanded treatment of single-ended self-balancing magnetic amplifiers, a survey of the static and dynamic performance characteristics of magnetic amplifiers with or without positive feed-back, and a chapter on application of magnetic-amplifier circuits for tracing of dynamic hysteresis loops.

Dictionary of Metallography. *By R. T. Rolfe; 287 pages, 5½ by 8½ in., clothbound; published by The Chemical Publishing Co. Inc., 212 Fifth Ave., New York 10, N. Y.; available from* MACHINE DESIGN, *$5.75 postpaid.*

Written for the metallurgist and engineer, this book is a compilation of definitions with encyclopedic treatment. Included are pertinent

Circle 555 on page 19

terms from collateral sciences, such as micrography, macrography, radiography, mechanical and magnetic testing, chemistry, physics, and physical chemistry.

Aircraft Hydraulic Design. *By George A. Kelbar, Flight Control Section, Autonetics Div., North American Aviation;* 130 *pages,* 6 *by* 9 *in., clothbound; published by and available from Applied Hydraulics Magazine, Cleveland;* $4.50 *per copy.*

This book deals with hydraulic component and system design for high-speed piloted aircraft and missiles. The first section of the book is devoted to basic theory treating properties of aircraft fluids, hydromechanics, and fluid flow through tubing. Practical equations are developed including those relating pressure gradient, flow path dimensions, flow rate velocity, fluid density, and viscosity.

Design of system components including actuators, valves, pumps, accumulators, transmission lines and seals is discussed in the second section, and hydraulic power servos and high-temperature hydraulic problems are discussed in the third section. Fundamentals of transient analysis technique and frequency response method of servo testing are given with a discussion of damping ratio.

Thermodynamics and Statistical Mechanics. *By A. H. Wilson;* 495 *pages,* 7½ *by* 10 *in., clothbound; published by New York Cambridge University Press,* 32 *East* 57*th St., New York* 22, *N. Y.; available from* MACHINE DESIGN, $9.50 *postpaid.*

This book covers both elementary and advanced topics, but elementary ideas are treated from an advanced standpoint. The first four chapters deal with the developments of thermodynamics. Nine chapters of the book consist of applications of thermodynamics and of statistical mechanics to a wide variety of problems. A special chapter is devoted to the third law of thermodynamics.

An Introduction to Semiconductors. *By W. Crawford Dunlap Jr., Bendix Aviation Corp., Mich.;* 417 *pages,* 6 *by* 9 *in., clothbound; published by*

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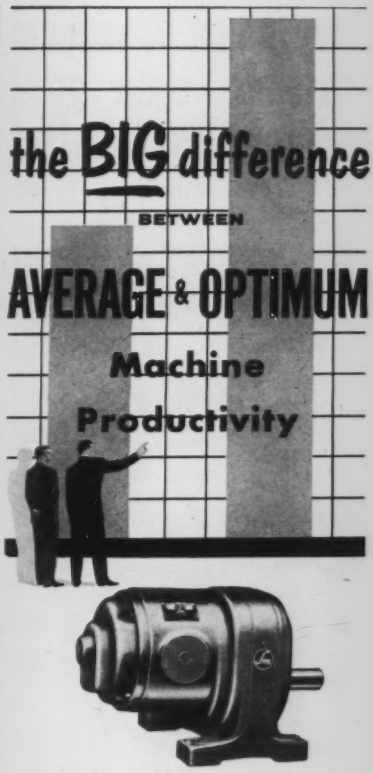

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Circle 557 on page 19

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Circle 558 on page 19

Library

John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from MACHINE DESIGN, $11.75 *postpaid.*

This is a single volume on semiconductors offering a complete coverage of the subject. It includes basic concepts, properties of materials, methods of measurement, and applications. It provides an elementary survey of transistors, rectifiers, and other semiconductor devices. The book is designed to provide a source of general information on all phases without an excess of detail or mathematics. The approach of the book is entirely physical, and the sections on devices emphasize the mechanisms and mode of operation of the devices.

Progress in Nuclear Energy, Series II, Reactors. *By R. A. Charpie, D. J. Hughes, D. J. Littler and M. Trocheris; 492 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, $14.00 *postpaid.*

This volume is the second in a series of eight on progress in nuclear energy. Information about competing types of reactors developed and built all over the world is presented. Contents include chapters on a prototype boiling-water power reactor; the graphite-moderated, gas-cooled pile; the sodium-cooled graphite reactor and a catalog section of world reactors.

Mechanical Vibrations. *By Bernard Morrill, Assoc. Prof. of Mechanical Engineering, Swarthmore College; 262 pages, 6 by 9 in., clothbound; published by The Ronald Press Co., 15 East 26th St., New York 10, N. Y.; available from* MACHINE DESIGN, $6.50 *postpaid.*

This book presents fundamental theory of mechanical vibrations. It introduces the solution of a second-order linear differential equation at an early point followed by partial derivatives so that the Lagrange equations can be developed. Solution of partial differential equations by separation of variables is then presented.

A final section covers background on analogy, mobility method, and applications of the analog

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Topics include dynamics of a particle, mathematics of a system of a single degree of freedom, systems with several degrees of freedom, beams and shafts, Lagrange equations, and vibrations in a continuous medium.

Differential Equations Applied in Science and Engineering. *By Harold Wayland, Div. of Engineering, California Institute of Technology;* 353 *pages,* 6 *by* 9 *in., clothbound; published by D. Van Nostrand Co. Inc.,* 120 *Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This book ties together processes of solving physical problems by mathematics. Not only does it analyze translation of physical concepts into mathematical language and carry through formal solution, but it also considers physical reasonableness of results.

Study of partial differential equations is the underlying theme of the book, since many problems of applied science can be described in terms of these equations. The author introduces important topics from advanced calculus to round out the presentation.

Vector concepts receive full attention, since they are useful in deriving certain partial differential equations. This approach in turn gives physical motivation for the study of vector analysis. Also emphasized is the method of separation of variables because it closely relates to techniques for solving ordinary differential equations. This treatment permits introduction of power series expansions, special functions, and expansion in series of orthogonal functions.

Government Publications

NACA Technical Series. *Each publication is* 8 *by* 10½ *in., paperbound; copies available from National Advisory Committee for Aeronautics,* 1924 *F St., N.W., Washington* 25, *D.C.*

The following Technical Notes are available:

3842. Creep Behavior of Structural Joints of Aircraft Material Under Constant Loads and Temperatures—53 pages.

3933. Effect of Fiber Orientation on Ball Failures Under Rolling-Contact Conditions—35 pages.

3936. Experimental Investigation of Temperature Feedback Control Systems Applicable to Turbo-Engine Control—56 pages.

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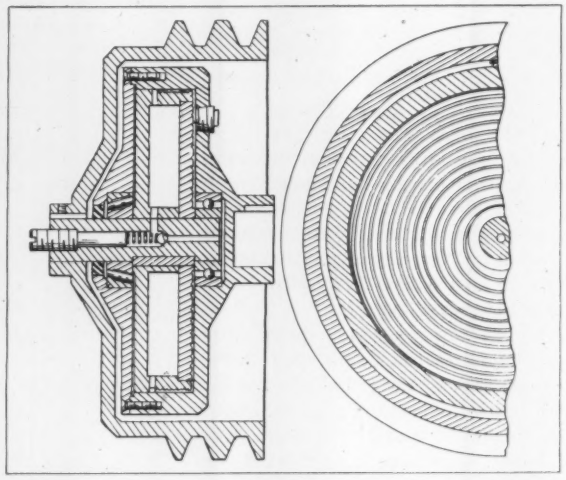
PURE CARBON CO., INC.
442 HALL AVENUE — ST. MARYS, PENNSYLVANIA

NOTEWORTHY

Patents

Speed-Limiting Pulley

Slip action between hydraulically coupled input and output members of a speed-limiting pulley holds output speed to a preset value. Effect is obtained by

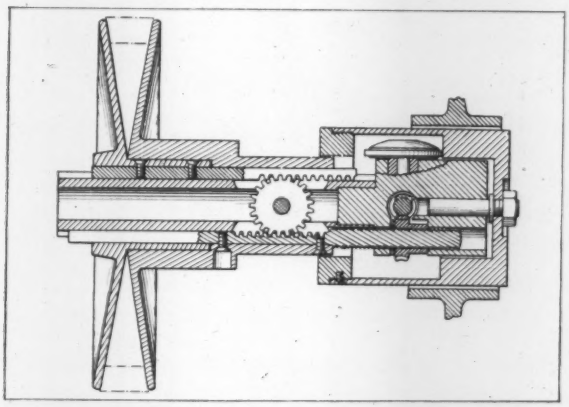


controlling circulation of hydraulic fluid between close fitting, spirally grooved internal facing surfaces of pulley components. As speed of input pulley (external shell) exceeds a predetermined limit — say, 1400 rpm—centrifugally developed pressure of the fluid opens a spring-loaded check valve, permitting circulation of fluid radially outward along the spiral grooves and into the central reservoir. Result is to hold speed of the output shaft constant at 1400 rpm regardless of further increases in input pulley speed. Application is intended where power from a variable-speed prime mover to a driven load must be limited to a predetermined maximum value. *Patent* 2,792,095 *assigned to Motor Products Corp. by Floyd A. Sherman.*

Adjustable-Pitch Pulley Control

Power for changing pitch comes from the pulley shaft itself in an adjustable-pitch-pulley control device. When no pitch change is required, the annular housing containing the roller and worm-gear assembly (right) revolves at shaft speed and no rotation is imparted to the roller. When housing rotation is stopped by an external brake, relative rotation between the roller (shown, for illustration, displaced 90 deg) and one end wall of the housing occurs. Direction of roller rotation (and pulley-pitch increase or decrease) depends upon which end of the housing the roller contacts. Roller rotation, with result-

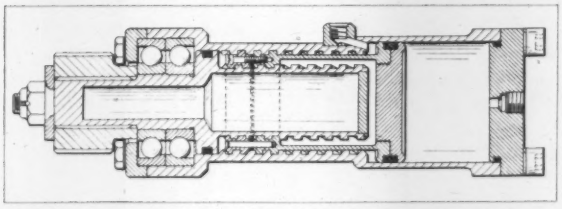
ing worm-wheel rotation, advances or retracts the lower toothed rack and the attached inner pulley half. The upper rack and the attached outer pulley half are translated in the opposite direction by rotation of the spur gear coupling the racks. While shown



here as an adjustable-pulley control, the mechanism offers a compact means for effecting relative axial displacement between any rotating-shaft and sliding-sleeve assembly. *Patent 2,792,712 assigned to Gerbing Mfg. Corp. by Harry Gibson.*

Rotary Actuator

Precise angular positioning with minimum backlash is provided by a fluid-operated rotary actuator. Reciprocation of the piston (right) is converted to rotary motion of the output shaft (left) by action of mating helical splines cut on the piston skirt and on the actuator output member. Splined portion of the



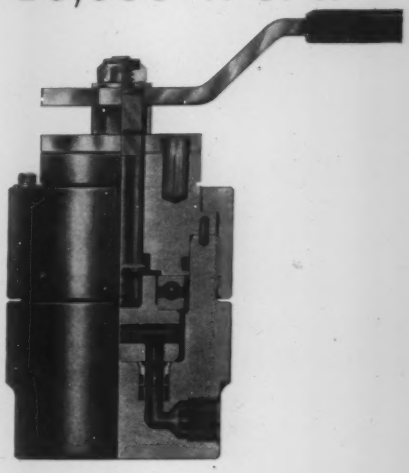
skirt, originally machined as an integral unit, is split transversely and reassembled with spacing shims (dashed lines), forming a splined member with misaligned teeth. Effect is to eliminate backlash, inherent in a conventional spline connection, between the translating piston and output shaft. *Patent 2,791,128 assigned to General Motors Corp. by Howard M. Geyer and James N. Tootle.*

Self-Engaging Clutch

Actuating weights of a self-engaging clutch—designed for duplicating machines or similar applications—move in response to both angular and centrifugal acceleration of the input member. As the belt-driven input pulley (center) accelerates to engaging speed, a combination of rotational inertia and centrif-

NEW 'SHEAR-SEAL' VALVE

FOR 10,000 P. S. I.



This new "Shear-Seal" shut-off valve rated for liquids or gases to 10,000 P.S.I. will withstand surges of up to 15,000 P.S.I. without damage to the valve or its leakproof operation. It is designed for a burst pressure of 40,000 P.S.I.

The "Shear-Seal" principle is an exclusive Barksdale development for the control of extreme pressures and has a long history of successful industrial application. Lapped optically flat sealing surfaces of the sealing rings and the mating rotor face are protected by keeping in constant intimate contact; flow is always through the center of the "Shear-Seal" never across sealing surfaces, as in conventional valve design. Sealing qualities actually improve as the self-aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation. The infinitesimal amount of wear is taken up by a back-up spring.

Valves will be furnished for pipe, tube, AND 150 or any preferred special high pressure connection. For complete information on the "Shear-Seal" design and its application in your particular high pressure valve problem write for "Shear-Seal" bulletin.

BARKSDALE VALVES

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Circle 561 on page 19

TITCHENER

cut the cost!

THE ORIGINAL MOTOR MOUNT and guard, left, cost $11.00, weighed 24 lbs. and contained an expensive cast frame. Working with the manufacturer, Titchener designed the simple wire mount and guard, shown at right. The new wire unit costs only $3.85 (a 65% saving!), weighs 13½ lbs., reduces noise and vibration.

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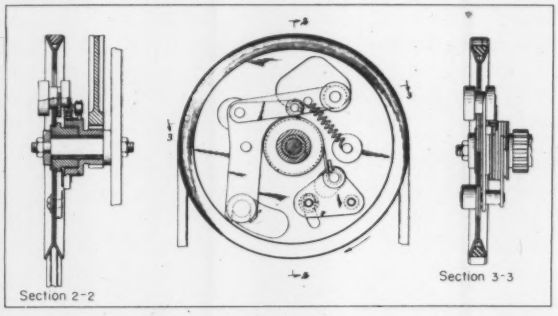
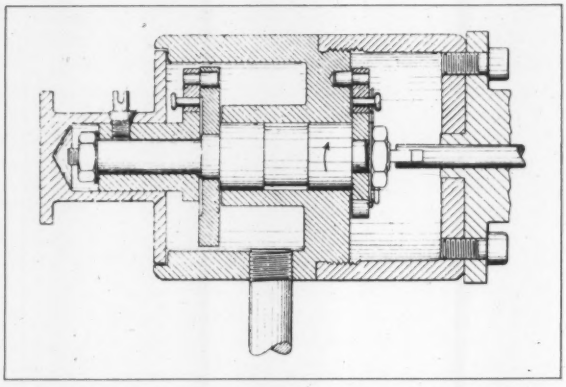
Noteworthy Patents



ugal force tightens a helical band, establishing an initially slipping connection between the drive-pulley disk and the central driven hub. Result is to give gradual engagement of the driven shaft with no jerking or chattering of either clutch or driven load. Disengagement similarly occurs in response to deceleration of the drive element, aided by an accompanying reduction of centrifugal forces and consequent release of the helical band. *Patent* 2,789,674 *assigned to A. B. Dick Co. by George J. Zahradnik and Edgar H. Du Bois.*

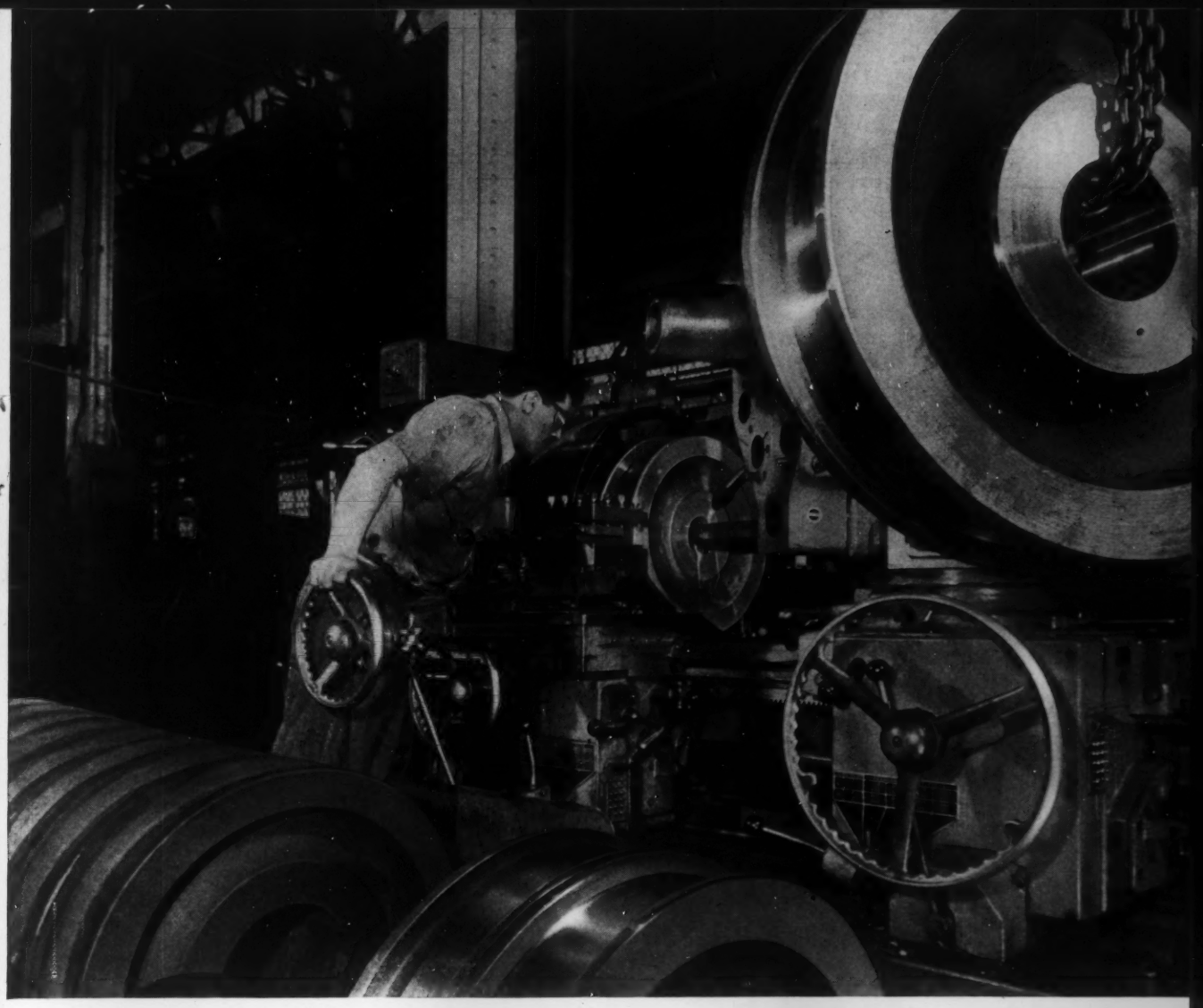
Linear Motion Totalizer

Rotational output of an intermittent motion converter and stroke totalizer represents the accumulated total of a linear reciprocating input motion in one selected direction. Conversion of motion (linear to rotational) is through a one-way clutch (left). Rotational motion of the output shaft during the reverse input stroke is blocked by a brake assembly (right). Intended for application in computers and similar devices, the device operates with minimum inertia and backlash. *Patent* 2,778,464 *assigned to Upjohn Co. by Leonard T. Cookson.*



Vibration-Actuated Safety Switch

Potentially destructive radial shaft vibrations, such as caused by load unbalance in high-speed rotating systems, are sensed and converted to appropriate control action by a vibration-sensitive switch. Shown here in a centrifugal laundry-extractor installation.



Thirty-Ton Cranes Will Roll on These Sturdy Wheels

This is a part of the machine shop of Industrial Crane & Hoist, Ingersoll Products Division, Borg-Warner Corporation, Chicago. Those big double-flange wheels, weighing 408 lb each and made from Bethlehem's tough, rugged circular forged blanks, will be used on bridge cranes that the company manufactures. The cranes have a capacity of thirty tons.

Obviously, strength is the first requirement that the wheels have to meet. Another is durability (flanges and tread must be long-wearing). Still a third is overall quality to match that of other components in the big cranes.

The wheels score a bull's-eye on every count, for the husky Bethlehem blanks from which they are made are both forged and rolled in a single operation—a unique process that insures high strength and a well-forged structure throughout.

Bethlehem blanks have many applications in addition to crane wheels. They are widely used for spur, bevel, and herringbone gears; flywheels, sheave wheels, and industrial wheels; turbine rotors, pipe flanges, and many other circular products. Available in a wide choice of sections, the blanks range in size from 10 to 46 in. OD. They can be furnished heat-treated or untreated.

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BETHLEHEM STEEL

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Circle 563 on page 19

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Circle 564 on page 19

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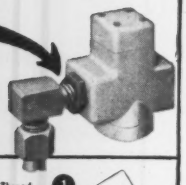
STOPS PIPE THREAD LEAKS



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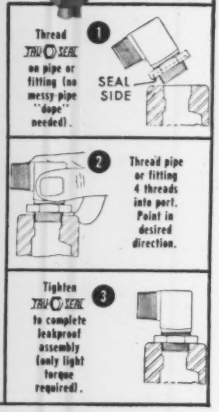
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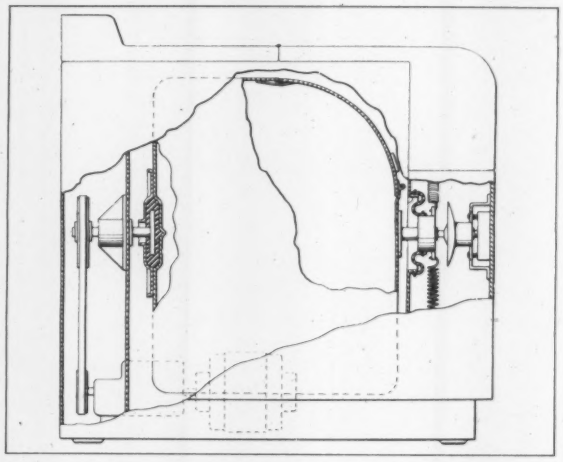
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Circle 565 on page 19

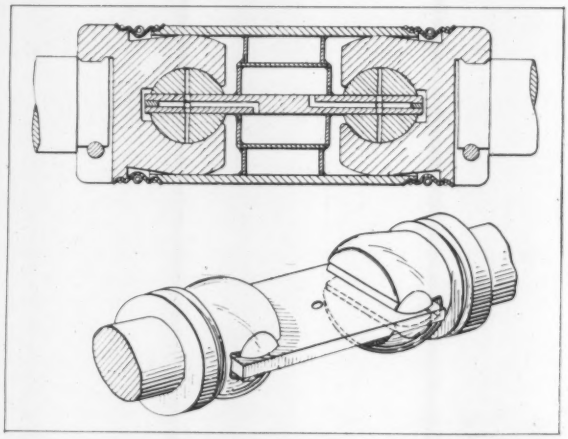
Noteworthy Patents



the protective-switch assembly (right) allows normal "whirling" excursion of the shaft end up to predetermined amplitude levels before it either shuts off power to the dryer or actuates automatic balancing devices. Normal axial shaft play, because of the dish-shaped operating plunger and mating cup design, will neither actuate the switch nor affect the transverse-vibration control point. *Patent* 2,782,655 *assigned to General Electric Co. by Aidan M. Stone.*

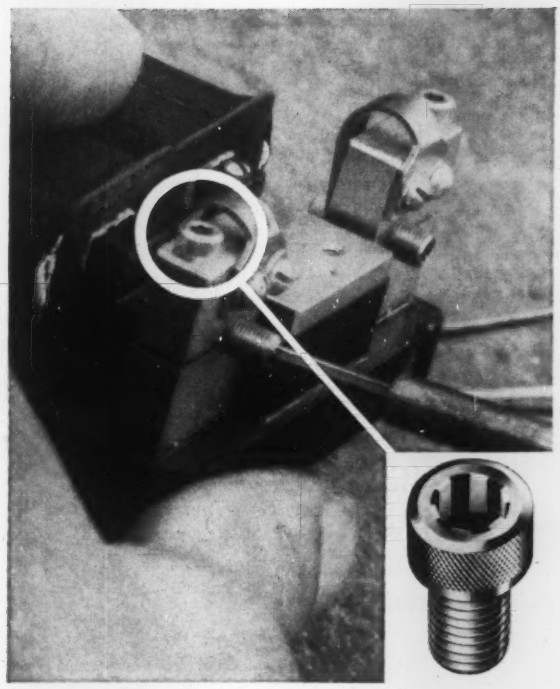
Heavy-Duty Shaft Coupling

Universal coupling, which accommodates both angular and axial displacements of connected shafts, utilizes a flat-strap torque-transfer member. Edge support for the strap and lubricant reservoir for the



spherical end balls is provided by a cylindrical shell. Typical use is for interconnecting rolls in a rolling-mill train. *Patent* 2,780,079 *assigned to SKF Industries Inc. by Ake Wahlberg.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.



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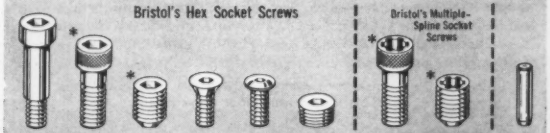

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½".

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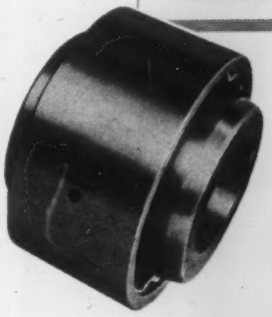

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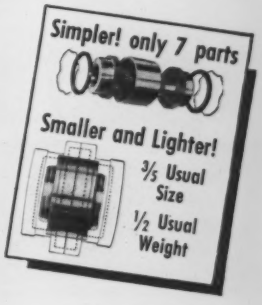

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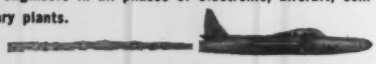

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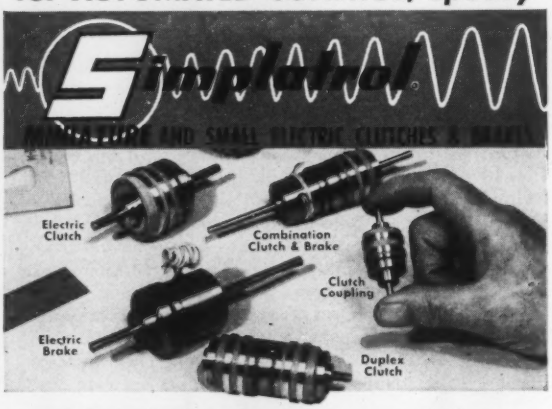
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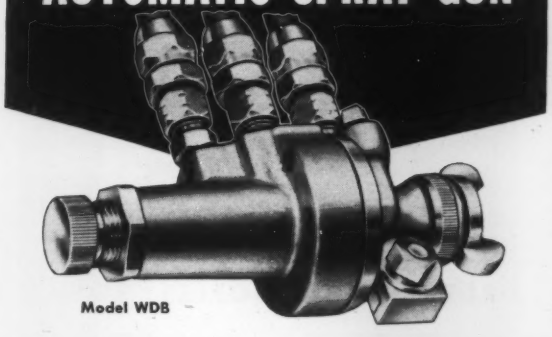
AUTOMATIC SPRAY GUN



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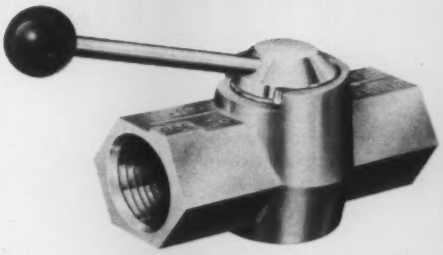
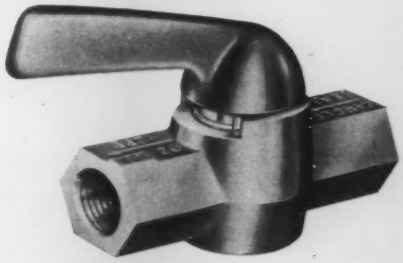
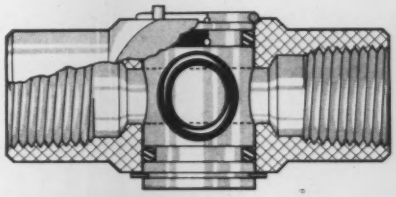
Circle Seal's



new



plug



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Circle 573 on page 19

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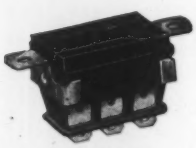

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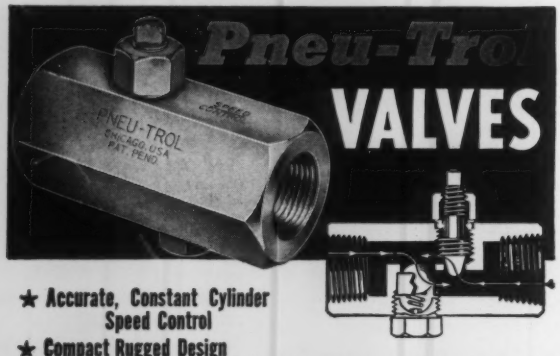

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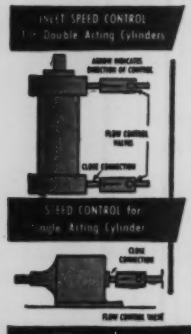

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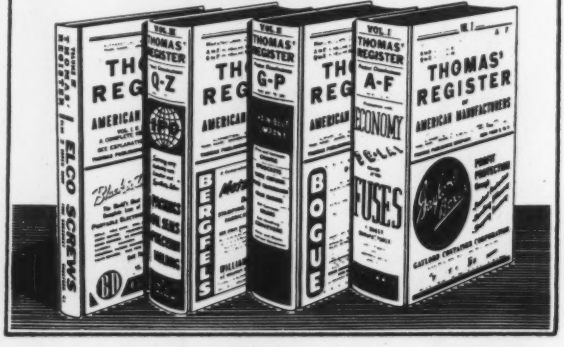

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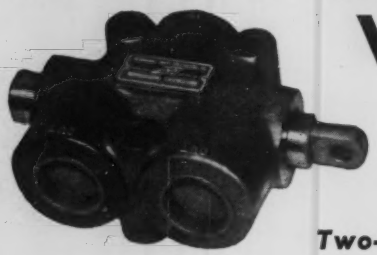

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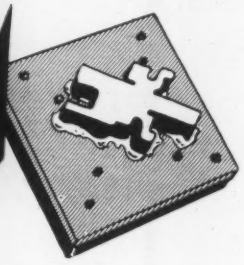

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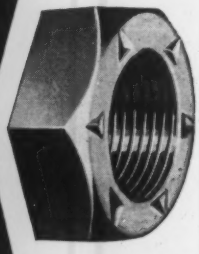

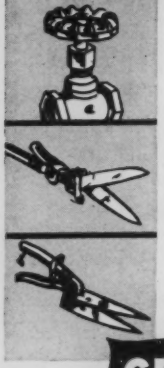

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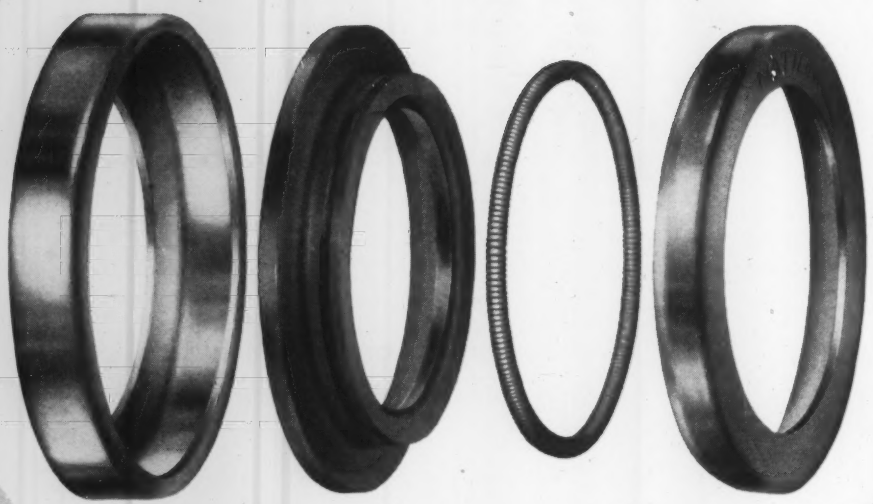

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Formed to extreme close tolerance of heavy gauge steel with sufficient structural strength to maintain precision dimension.

b. Sealing Lip

Properly prescribed material either compounded or processed for application conditions of temperature and eccentricities. Precisely molded for correct shaft interference, low torque and positive sealing.

c. Tension Spring

Carefully engineered as to metallurgy, heat treatment and coil diameter to provide uniform compressive force on the sealing element.

d. Inner Case

Strengthens, protects; sturdy gauge steel formed to close tolerances.

4227

A good oil seal is a carefully engineered, precision manufactured assembly of carefully engineered, precision manufactured components. Each part must be exactly right *for the given application* or the seal will not function properly.

You avoid dangers of costly retooling, remanufacture or premature replacement when seals are correctly specified during your product's design stage. Each sealing application is different; many designers use National's field engineering service to be sure correct—and latest—oil seals are used.

Why "do it yourself?" Call the National Seal field engineer now. His service involves no obligation.

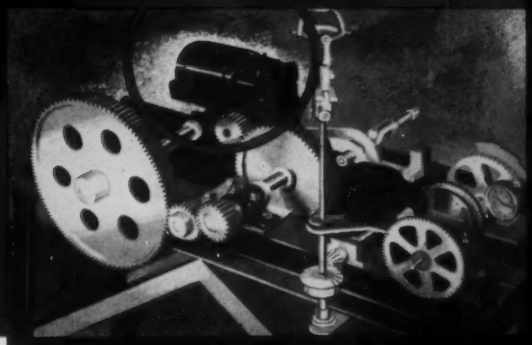
NATIONAL SEAL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio, Redwood City and Downey, California

CATALOGS IN SWEET

36th year

CHICAGO, ILL. . . *Room 462, McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DETROIT, MICH. . . . . *13836 Puritan Avenue, VErmont 6-1909*
DOWNEY (Los Angeles County), CALIF. . . *11634 Patton Road, TOpaz 2-8163*
INDIANAPOLIS, INDIANA . *2802 North Delaware Street, WAlnut 3-1535*
MILWAUKEE, WIS. . . *647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J. . . . . *1180 Raymond Blvd., MItchell 2-7586*

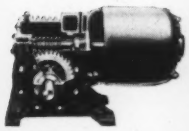
Nothing Cuckoo about this clock!



The "works" of a tower clock. ⅓ H.P., 115/230 volt, 60 cycle, 1 phase Master Right Angle Gearmotor supplies main drive with a synchronous output speed of 30 R.P.M.

You may not need clock drives, but time (production time) is a problem everywhere—and that calls for the most dependable, most efficient use of electric drives—like here! This clock, with 300 lbs. of hands and four 24-foot dials is powered by a Master Gearmotor driving a precision gear train. With that accurate Master drive, here's a one-jewel clock!

Are you sure you've got the right answer to your drive requirements? Master components can be integrated in any combination to give you the right horsepower, right shaft speed, right mounting features, in a single, efficient, compact unit. Now's the time to let us prove it.



MASTER ELECTRIC MOTORS

ANOTHER DRIVE REQUIREMENT MEETS ITS MASTER

Motor Ratings	⅛ to 400 H.P. All phases, voltages, frequencies.
Motor Types	Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.
Construction	Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.
Speeds	Single-speed, multi-speed, and variable speed.
Installation	Horizontal and vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY

Dayton 1, Ohio

Circle 402 on page 19

ANNOUNCING!

Increased capacity ratings for Timken® bearings

THE Timken Roller Bearing Company announces an increase in the capacity ratings of most series of Timken® tapered roller bearings. Increases range up to 39%. Most are in the neighborhood of 10%. Some are negligible.

Permits Use of Smaller Bearings

This increase in capacity ratings makes it possible for many of you to use smaller bearings. Your products can be made more compact. You can save weight. You may be able to reduce the size of your shafts and housings. And you may be able to use Timken bearings in new applications where they have not been practicable in the past.

3 Reasons for Increases

What led to these increases in Timken bearing capacities? Three things:

First, a careful review of more than 6,000 different laboratory studies of Timken bearing performance on fatigue life machines. From these exhaustive studies, conducted on an organized, scientific basis since 1924, we keep learning more and more about predicting bearing life.

Second, refinement in the method of analyzing these studies mathematically.

Third, a careful review of the life of millions of Timken bearings in the field.

How Much Can This Save *You?*

To find out how the new capacity ratings affect the types and sizes of Timken bearings in which you are interested, call your Timken bearing representative or write our Engineering Department. We'll be glad to work with you at the drawing board stage. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

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